TRUCK SHOP MANUAL
1989
VOLUME B
LIGHT DUTY TRUCK
E, F-150 through 350, F-Super Duty, Bronco
ENGINE

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Cooling System (8000)	27
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Ford Parts and Service Division
Publications Department

IMPORTANT SAFETY NOTICE

Appropriate service methods and proper repair procedures are essential for the safe, reliable operation of all motor vehicles as well as the personal safety of the individual doing the work. This Shop Manual provides general directions for accomplishing service and repair work with tested, effective techniques. Following them will help assure reliability.

There are numerous variations in procedures, techniques, tools, and parts for servicing vehicles, as well as in the skill of the individual doing the work. This Manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Accordingly, anyone who departs from the instructions provided in this Manual must first establish that he compromises neither his personal safety nor the vehicle integrity by his choice of methods, tools or parts.

NOTES, CAUTIONS, AND WARNINGS

As you read through the procedures, you will come across NOTES, CAUTIONS, and WARNINGS. Each one is there for a specific purpose. NOTES give you added information that will help you to complete a particular procedure. CAUTIONS are given to prevent you from making an error that could damage the vehicle. WARNINGS remind you to be especially careful in those areas where carelessness can cause personal injury. The following list contains some general WARNINGS that you should follow when you work on a vehicle.

- Always wear safety glasses for eye protection.
- Use safety stands whenever a procedure requires you to be under the vehicle.
- Be sure that the ignition switch is always in the OFF position, unless otherwise required by the procedure.
- Set the parking brake when working on the vehicle. If you have an automatic transmission, set it in PARK unless instructed otherwise for a specific operation. If you have a manual transmission, it should be in REVERSE (engine OFF) or NEUTRAL (engine ON) unless instructed otherwise for a specific operation. Place wood blocks (4" x 4" or larger) to the front and rear surfaces of the tires to provide further restraint from inadvertent vehicle movement.
- Operate the engine only in a well-ventilated area to avoid the danger of carbon monoxide.
- Keep yourself and your clothing away from moving parts, when the engine is running, especially the fan and belts.
- To prevent serious burns, avoid contact with hot metal parts such as the radiator, exhaust manifold, tail pipe, catalytic converter and muffler.
- Do not smoke while working on the vehicle.
- To avoid injury, always remove rings, watches, loose hanging jewelry, and loose clothing before beginning to work on a vehicle. Tie long hair securely behind the head.
- Keep hands and other objects clear of the radiator fan blades. Electric cooling fans can start to operate at any time by an increase in underhood temperatures, even though the ignition is in the OFF position. Therefore, care should be taken to ensure that the electric cooling fan is completely disconnected when working under the hood.

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foreword . . .

This 1989 Truck Shop Manual has been prepared to provide information covering normal Engine and related systems service repairs and maintenance for the 1989 Bronco, Econoline (E-150 through E-350), F-150 through F-350 Series and F-Super Duty Ford Trucks manufactured in the United States and Canada. Refer to the 1989 Engine/Emissions Diagnosis Manual for additional engine and emissions diagnosis information.

Body, Chassis, Electrical, and Pre-Delivery, Maintenance and Lubrication service repairs are covered in the 1989 Light Truck Body, Chassis and Electrical Shop Manual and the 1989 Truck Pre-Delivery Shop Manual.

This manual is divided into Groups covering a general system. The basic part number for components covered in the Group is also included in parenthesis after the Group number. For example:

Cooling System	Group 27	(8000)
General System Covered in Group	Group Number	Basic Part Number for Cooling System Components

Some components covered within a Group do not have the same basic part number. In these cases, more than one basic part number will appear on the Group index. For example:

Gasoline Engines	Group 21	(6000	&	9000)
General System Covered in Group		Basic Part Number for Gasoline Engine Components		Intake and Exhaust Manifold Basic Part Number Only

Within each Group, the information is further divided into smaller Sections. There is one Section for each component in the system, as well as a General Service Section in some Groups to cover procedures common to several Sections within the Group. In general, each Section contains the Description, Operation, Diagnosis and Testing, Removal and Installation and Disassembly and Assembly procedures for the component covered in the Section. Diagnosis Charts are also included in some Sections to help you systematically locate and correct problems encountered. In most cases, specifications are included at the end of each Section.

To aid in locating specific items in this manual, use the Alphabetical Subject Index in the back of the manual, or the Group and Section Index on the following pages.

As a further aid there is an index on the first page of each Group listing the Section title and Basic Part number for components covered within the Group. The first page of each Section contains an index to locate service operations covered in that section. This Group-Section breakdown is also indicated in the page number located at the top of each page.

Example: 21-01-10 = (Group) 21 — (Section) 01 — (Page) 10

The descriptions, testing procedures, and specifications in this manual were in effect at the time the manual was approved for printing. Ford Motor Company reserves the right to discontinue models at any time, or change specifications, design or testing procedures without notice and without incurring obligation. Any reference to brand names in this manual is intended merely as an example of the types of tools, lubricants, materials, etc. recommended for use. Equivalents if available may be used. The right is reserved to make changes at any time without notice.

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Training and Publications Department
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Truck Shop Manual Cross Reference Index

Volume	Content	Vehicle Lines
A	Body, Chassis, Electrical	Bronco, Econoline (E-150 through E-350) and F-150 through F-350, F-Super Duty
B	Engine	Bronco, Econoline (E-150 through E-350) and F-150 through F-350, F-Super Duty
D	Body, Chassis, Electrical	F-, FT-, B-, C-600 through 8000 Series
E	Engine	F-, FT-, B-, C-600 through 8000 Series
F	Pre-Delivery, Hoisting and Jacking	Car Models and Truck Series
H	Engine/Emissions Diagnosis	Car Models and Truck Series

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GROUP

IDENTIFICATION CODES 20

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VEHICLE APPLICATION

E-150 Through E-350, F-150 Through F-350, F-Super Duty, Series and Bronco Vehicles.

GENERAL INFORMATION

Vehicle Safety Compliance Certification Label

The English Safety Compliance Certification Label is attached to the driver's door lock pillar (Figs. 1 and 2). The French Safety Compliance Certification Label is attached to the door latch edge on the passenger's side door (Fig. 1). The label contains the name of the manufacturer, the month and year of manufacture, the certification statement, and the Vehicle Identification Number. The label also contains Gross Vehicle Weight Rating and Gross Axle Weight Ratings, wheel and tire data, and information codes for additional vehicle data.

Vehicle Identification Number (VIN)

Refer to Fig. 3

A seventeen digit combination of numbers and letters forms the Vehicle Identification Number (VIN). The VIN is stamped on a metal tab that is riveted to the instrument panel close to the windshield. The VIN number is viewable by looking through the front windshield on the driver's side. The VIN number is also found on the Vehicle Safety Compliance Certification Label.

By looking at the seventeen digit VIN number a variety of information about the vehicle can be determined. The first three digits identify the manufacturer and the vehicle make and type. The fourth digit determines the Gross Vehicle Weight Rating (GVWR) Class and Brake System for Ford completed Trucks and MPV's. For Buses and Incompleted vehicles, the fourth digit determines the brake system only. Digits five, six and seven identify the model or line, series, chassis and cab or body type. The eighth digit points out the particular engine found in the vehicle. Digit nine is the VIN check digit. The tenth digit identifies the model year of a Ford—completed vehicle, or the model year of the incomplete vehicle, if sold by Ford as an incomplete vehicle. The eleventh digit determines the assembly plant. Digits twelve through seventeen make up the sequence serial and warranty number. Digit twelve uses the letter "J" until the production or sequence of 99,999 units (digits thirteen through seventeen) is reached. Letter "J" then becomes "K" for the next production sequence of vehicles.

Refer to Fig. 3 to help in further explanation of the Vehicle Identification Number (VIN).

Refer to the code definition portion of this Section for specific definitions of the numbers and letters of the Vehicle Identification Number (VIN).

Build Date Stamp Locations

The vehicle build date stamp is located as follows: On Bronco and Light Trucks (F-150—F-250—F-350) the vehicle build date is stamped on the front surface of the radiator support on the passengers side of the vehicle. On Econoline vehicles, (E-150—E-250—E-350) the build date is stamped on top of the radiator support. Following is a sample of the four digit number that indicates the month and day of build.

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Actual Date of Build

Date Stamp on Vehicle

January 24—0124

October 21—1021

Yellow ink is used for the date stamp. When the marking surface is painted the body color, the date stamp will be marked in red ink. Units from the Ontario Truck Plant (Code C) will be marked with silver ink.

Vehicle Data

The Vehicle Data appears on the Safety Compliance Certification Label on the second and third lines following the identification number. The code set (two numbers, or a number and letter) above COLOR identfy the exterior paint color (two sets of codes designated a two-tone). The letter and three digits under TYPE/ G.V.W. designate the truck model within a series and the gross vehicle weight rating. The letters and/or numeral under BODY designate the interior trim, seat and body type. The transmission installed in the vehicle is identified under TRANS by an alphabetical code. A letter and a number or two numbers under AXLE identify the rear axle ratio (when required, a letter or number is also stamped after the rear axle code to identify the front axle). The letters and/or numerals under TAPE designate the external bodyside tape stripe. The spring usage codes for the vehicle is identified under SPRING.

A two-digit number is stamped above D.S.O. to identify the district which ordered the vehicle. If the vehicle is built to special order(Domestic Special Order, Foreign Special Order, Limited Production Option, or other special order), the complete order number will also appear above D.S.O. The following charts list the various vehicle data codes.

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SAFETY COMPLIANCE CERTIFICATION LABELS
COMPLETE VEHICLES

(UNITED STATES)

MFD. BY FORD MOTOR CO. IN U.S.A.
DATE: 2/88 GVWR: 4900 LB/2222 KG

FRONT GAWR: 2684 LB		REAR GAWR: 3750 LB	
1217 KG	WITH	1700 KG	WITH
P195/75R15SL	TIRES	P195/75R15SL	TIRES
15x6 0 JK	RIMS	15x6 0 JK	RIMS
AT 35 PSI COLD		AT 35 PSI COLD	

THIS VEHICLE CONFORMS TO ALL APPLICABLE FEDERAL MOTOR VEHICLE SAFETY STANDARDS IN EFFECT ON THE DATE OF MANUFACTURE SHOWN ABOVE

VEHICLE IDENTIFICATION NO.
1FTBF15G5 KLA00000
TYPE TRUCK

EXTERIOR PAINT COLORS					DSO	
WB	TYPE GVW	BODY	TRANS	AXLE	TAPE	SPRING

(CANADA)

MFD. BY FORD MOTOR CO. OF CANADA LTD.
DATE: GVWR:

FRONT GAWR:		REAR GAWR:	
	WITH		WITH
	TIRES		TIRES
	RIMS		RIMS
AT PSI COLD		AT PSI COLD	

THIS VEHICLE CONFORMS TO ALL APPLICABLE FEDERAL MOTOR VEHICLE SAFETY STANDARDS IN EFFECT ON THE DATE OF MANUFACTURE SHOWN ABOVE

VEH. IDENT. NO.
TYPE UTILIZE SAME TYPE DATA AS U S A

EXTERIOR PAINT COLORS					DSO	
WB	TYPE GVW	BODY	TRANS	AXLE	TAPE	SPRING

MADE IN CANADA

(QUEBEC)

FABR. AUX E-U PAR LA FORD MOTOR CO.
DATE: PNBV:
PNBE AV PNBE AR
AVEC
◂PNEUS▸
◂JANTES▸
A LB/PO² A FROID A LB/PO² A FROID

CE VEHICULE EST CONFORME A TOUTES LES NORMES FEDERALES DE SECURITE DES V.A. EN VIGUEUR A LA DATE DE FABR. INIQUEE CI-DESSUS.

N° D'IDENT.
DU VEH.
TYPE

COULEUR					N° COMM SPEC	
EMPATT	TYPE/PBV	CARR	TRANSM	PONT	BANDE	RESSORT

FOR VEHICLES MFD IN U S A FOR QUEBEC CANADA

(QUEBEC)

FABR. PAR FORD DU CANADA LIMITEE
DATE: PNBV:
PNBE AVANT: PNBE ARRIERE:
AVEC
◂PNEUS▸
◂JANTES▸
A LB/PO² A FROID A LB/PO² A FROID

CE VEHICULE EST CONFORME A TOUTES LES NORMES FEDERALES DE SECURITE DES V A EN VIGUEUR A LA DATE DE FABR. INIQUEE CI-DESSUS.

N° D'IDENT
DU VEH.
TYPE

COULEUR					N° COMM SPEC	
EMPATT	TYPE/PBV	CARR	TRANSM	PONT	BANDE	RESSORT

MADE IN CANADA

FOR VEHICLES MFD IN CANADA FOR QUEBEC, CANADA

INCOMPLETE VEHICLES

THE INCOMPLETE VEHICLE RATING DECAL IS INSTALLED ON THE DRIVER S DOOR LOCK PILLAR IN PLACE OF THE SAFETY COMPLIANCE CERTIFICATION LABEL

DECAL APPLIED TO ALL CANADIAN BUILT UNITS AND ALL U S A BUILT UNITS SOLD IN CANADA

INCOMPLETE VEHICLE MANUFACTURED BY

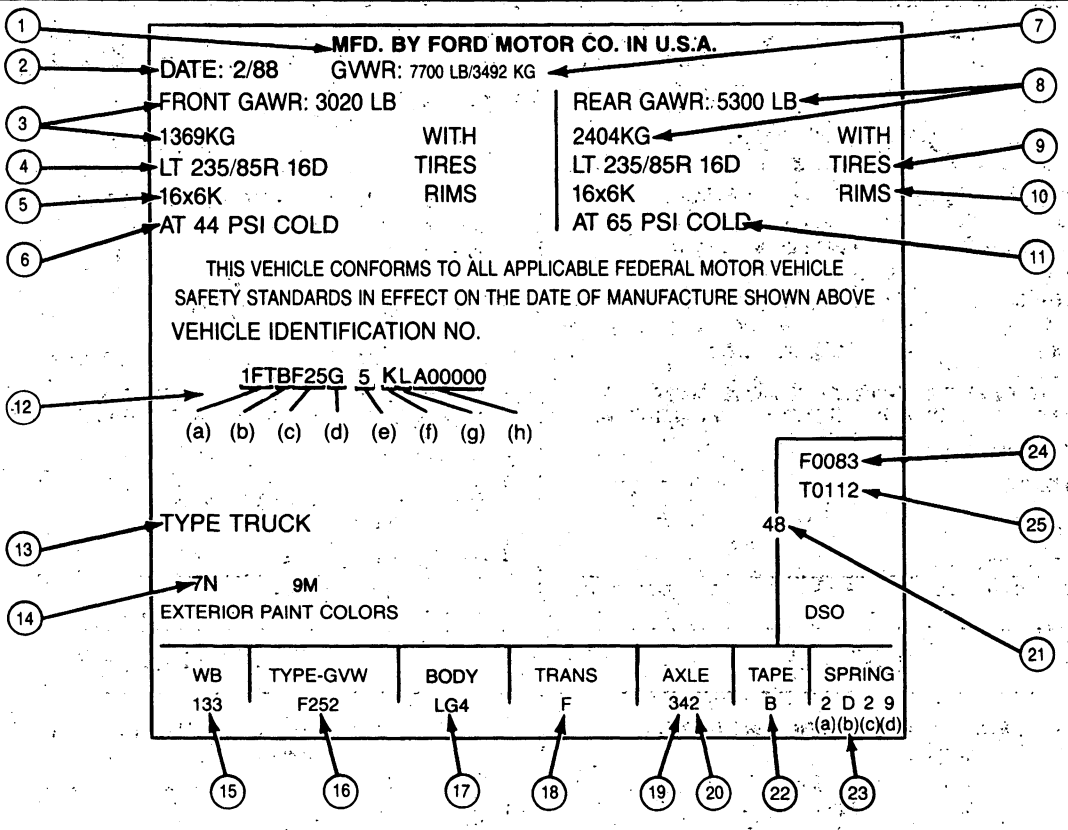
GVWR: 3020 LB/1369 KG
VEHICLE IDENTIFICATION NUMBER 1FTBF25G5 KLA00000

EXTERIOR PAINT COLORS	51				48 DSO	
WB	TYPE GVW	BODY	TRANS	AXLE	TAPE	SPRING 2D29
133	F270	AB4	F	38	B	1988

CY2666-2F

FIG. 1 Typical Truck Safety Compliance Certification Labels and Vehicle Rating Decal

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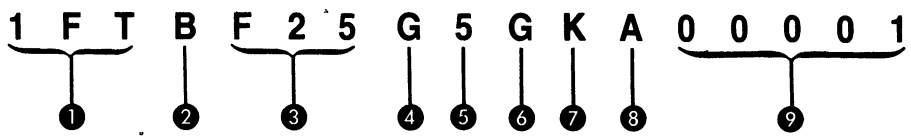
① Name and Location of Manufacturer
② Date of Manufacture
③ Front Gross Axle Weight Ratings in Pounds (LB) and Kilograms (KG)
④ Front Tire Size
⑤ Rim Size
⑥ Front Tire Cold PSI
⑦ Gross Vehicle Weight Rating in Pounds (LB) and Kilograms (KG)
⑧ Rear Gross Axle Weight Rating in Pounds (LB) and Kilograms (KG)
⑨ Rear Tire Size
⑩ Rim Size
⑪ Rear Tire Cold PSI
⑫ Vehicle Identification Number
(a) World Manufacturer Identifier
(b) Brake System and Gross Vehicle Weight Rating (GVWR) Class for Ford completed Trucks and MPV's. For Buses and Incomplete Vehicles, the fourth digit determines the brake system (only).
(c) Model or Line, Series, Chassis, Cab or Body Type
(d) Engine Type
(e) Check Digit
(f) Model Year (Ford-Complete Trucks and MPV's)
(g) Assembly Plant Code
(h) Sequence Number
⑬ Type Vehicle
⑭ Exterior Paint Codes (two sets of figures designates a two-tone)
⑮ Wheelbase in Inches
⑯ Model Code and GVW
⑰ Interior Trim, Seat and Body/Cab Type
⑱ Transmission Code
⑲ Rear Axle Code
⑳ Front Axle Code if so Equipped
㉑ District/Special Order Codes
㉒ External Body Tape Stripe Code
㉓ Suspension Identification Codes
(a) Aux./Opt. Usage Code (Front)
(b) Front Spring Code
(c) Aux./Opt. Usage Code (Rear)
(d) Rear Spring Code
㉔ Front Axle Accessory Reserve Capacity in Pounds
㉕ Total Accessory Reserve Capacity in Pounds

CW1017-2W

FIG. 2 Typical Truck Safety Compliance Certification Label

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SAMPLE VIN NUMBER



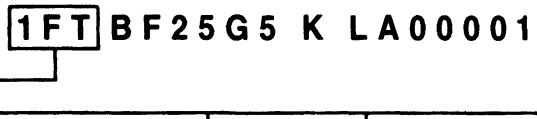
1. Position 1, 2 and 3 — Manufacturer, Make and Type (World Manufacturer Identifier)
2. Position 4 — Brakes System/GVWR Class for Ford-completed Trucks and MPV's For Buses and Incomplete Vehicles, Brake System (only)
3. Position 5, 6 and 7 — Model or Line, Series, Chassis, Cab or Body Type
4. Position 8 — Engine Type
5. Position 9 — Check Digit
6. Position 10 — Model Year (Ford-completed vehicles)
7. Position 11 — Assembly Plant
8. Position 12 — Constant "A" until sequence number of 99,999 is reached, then changes to a constant "B" and so on
9. Position 13 through 17 — Sequence number — begins at 00001

CY2376-2H

FIG. 3 Vehicle Identification Number (VIN)

Vehicle Identification Number (VIN) Codes

WORLD MANUFACTURER IDENTIFIER
(VIN POSITIONS 1, 2 AND 3)



VIN Code	Manufacturer	Make	Type
1FM	Ford Motor Company, USA	Ford	Multi-Purpose Passenger Vehicle (MPV)
1FT	Ford Motor Company, USA	Ford	Truck (Complete Vehicle)
1FD	Ford Motor Company, USA	Ford	Incomplete Vehicle (IV)
1FC	Ford Motor Company, USA	Ford	Basic (Stripped) Chassis
1FB	Ford Motor Company, USA	Ford	Bus
1FF	Ford Motor Company, USA	Ford	Motor Vehicle Equipment without Engine/Powertrain (Glider)
2FM	Ford Motor Company of Canada, Ltd	Ford	MPV
2FT	Ford Motor Company of Canada, Ltd	Ford	Truck (Complete Vehicle)
2FD	Ford Motor Company of Canada, Ltd	Ford	Incomplete Vehicle
2FC	Ford Motor Company of Canada, Ltd	Ford	Basic (Stripped) Chassis
2FB	Ford Motor Company of Canada, Ltd	Ford	Bus
2FF	Ford Motor Company of Canada, Ltd	Ford	Motor Vehicle Equipment without Engine/Powertrain (Glider)
3DF	Ford Motor Company of Mexico	Ford	Incomplete Vehicle (IV)

CY2377-2H

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BRAKE SYSTEM AND GVWR CLASS FOR TRUCKS AND MPV'S — BRAKE SYSTEM (ONLY) FOR BUSES AND INCOMPLETE VEHICLES (VIN POSITION 4)

1FT[B]F25G5KLA00001

BRAKE SYSTEM	GVWR CLASS	GVWR RANGE	VIN CODE
Hydraulic	Class A	Not greater than 3,000 pounds	A
Hydraulic	Class B	3,001 — 4,000 pounds	B
Hydraulic	Class C	4,001 — 5,000 pounds	C
Hydraulic	Class D	5,001 — 6,000 pounds	D
Hydraulic	Class E	6,001 — 7,000 pounds	E
Hydraulic	Class F	7,001 — 8,000 pounds	F
Hydraulic	Class G	8,001 — 8,500 pounds	G
		8,501 — 9,000 pounds	H
Hydraulic	Class H	9,001 — 10,000 pounds	J
Hydraulic	Class 3	10,001 — 14,000 pounds	K
Hydraulic	Class 4	14,001 — 16,000 pounds	L
Hydraulic	Class 5	16,001 — 19,500 pounds	M

CY2674-2F

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MODEL OR LINE, SERIES, CHASSIS, CAB OR BODY TYPE (VIN POSITIONS 5, 6, AND 7)

1FTB [F25] G5KLA00001

VIN Code		Line	Series	ChassisType	Cab or Body Type	Vehicle Type ①
Club Wagon	Super Wagon					
E11	—	Club Wagon XL	E150	4x2	Club Wagon	MPV
E21	—	Club Wagon XL	E250	4x2	Club Wagon	MPV or Bus ⓐ
—	S31	Club Wagon XL	E350	4x2	Super Wagon	MPV or Bus ⓐ

Memo: One of the following optional exterior nameplates (indicating different trim levels) may also be affixed to the vehicle in addition to the Club Wagon XL nameplate:
●XLT ●No Nameplate (Trim credit option-deletes XL trim components) ⓐExcludes School Bus

Regular Van	Super Van					
E14	S14	Econoline	E150	4x2	Cargo Van — Regular Van/Super Van	Truck or IV
E24	S24	Econoline	E250	4x2	Cargo Van — Regular Van/Super Van	Truck or IV
E34	S34	Econoline	E350	4x2	Cargo Van — Regular Van/Super Van	Truck or IV
Other						
E37	—	Econoline	E350	4x2	Commercial Cutaway	IV
E30	—	Econoline	E350	4x2	RV Cutaway	IV
E39	—	Econoline	E350	4x2	Commercial Basic (Stripped) Chassis	IV
E33	—	Econoline	E350	4x2	RV Basic (Stripped) Chassis	IV

①"MPV" means Multi-Purpose Vehicle. "IV" means Incomplete Vehicle. "Truck" means Complete Vehicle.
Memo: For all Econoline except Basic (Stripped) Chassis, the optional exterior nameplate "XL" (indicating trim level) may also be affixed to the vehicle in addition to the Econoline nameplate.
Note: All 1988 model Commercial and RV Basic (Stripped) Chassis incomplete vehicles are designated by a "1FC" or "2FC" World Manfacturer Identifier (WMI) code. The RV Basic (Stripped) Chassis is available only on a Special Order Basis.

VIN Code	Line	Series	Chassis Type	Cab or Body Type	Vehicle Type ①
U15	Bronco	U150	4x4	Bronco	MPV

Memo: One of the following optional exterior nameplates (indicating higher trim levels) may also be affixed to the vehicle in addition to the Bronco nameplate:
● XLT ● Eddie Bauer

Regular Cab	Super Cab or Crew Cab					
F14	X14	F-Series	F150	4x4	Pickup — Regular Cab/Super Cab	Truck
F15	X15	F-Series	F150	4x2	Pickup — Regular Cab/Super Cab	Truck
F25	X25	F-Series	F250	4x2	Pickup — Regular Cab/Super Cab	Truck
F26	X26	F-Series	F250	4x4	Pickup — Regular Cab/Super Cab	Truck
F35	W35X35	F-Series	F350	4x2	Pickup — Regular Cab/Crew Cab	Truck
F37	—	F-Series	F350	4x2	Regular Cab (Chassis Cab)	IV
F36	W36	F-Series	F350	4x4	Pickup — Regular Cab/Crew Cab	Truck
F38	—	F-Series	F350	4x4	Regular Cab (Chassis Cab)	IV
F47	—	F-Series	F-Super Duty	4x2	Regular Cab (Chassis Cab)	IV
F53	—	F-Series	F-Super Duty	4x2	RV Basic Stripped Chassis	IV
F59	—	F-Series	F-Super Duty	4x2	Commercial Basic Stripped Chassis	IV

① "MPV" means Multi-Purpose Passenger Vehicle. "IV" means Incomplete Vehicle.
Memo: One of the following optional exterior nameplates (indicating higher trim levels) may also be affixed to the vehicle in addition to the F-Series nameplates:
● XL ● XLT Lariat ● Explorer (excluding Crew Cab and Chassis Cab)
Note: Special Order (DSO) units will be coded with the appropriate series VIN codes listed above.

CY2379-2H

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ENGINE TYPE, DISPLACEMENT, CYLINDERS, FUEL TYPE, AND MANUFACTURER (VIN POSITION 8)

1 F T B F 2 5 [G] 5 K L A 0 0 0 0 1

VIN Code	Displacement		Cylinders	Fuel	Manufacturer
	Liter	CID			
Y	4.9	300	I-6	Gasoline	Ford
N	5.0	302	V-8	Gasoline	Ford
H	5.8	351	V-8	Gasoline	Ford
G	7.5	460	V-8	Gasoline	Ford
M	7.3	445	V-8	Diesel	Navistar

CY2380-2H

CHECK DIGIT FOR ALL VEHICLES (VIN POSITION 9)

1 F T B F 2 5 G [5] K L A 0 0 0 0 1

CY2381-1H

VEHICLE MODEL YEAR FOR FORD-COMPLETED VEHICLES (VIN POSITION 10)

1 F T B F 2 5 G 5 [K] L A 0 0 0 0 1

VIN Code	Year
K	1989
L	1990
M	1991
N	1992

CY2382-1H

ASSEMBLY PLANT CODES (VIN POSITION 11)

1 F T B F 2 5 G 5 K [L] A 0 0 0 0 1

VIN Code	Vehicle Assembly Plant — Name and Location
C	Ontario Truck: Oakville, Ontario
H	Lorain: Lorain, Ohio
J	Monterrey, N.L.: Mexico
K	Kansas City: Claycomo, Missouri
L	Michigan Truck: Wayne, Michigan
N	Norfolk: Norfolk, Virginia
P	Twin Cities: St. Paul, Minnesota
U	Louisville: Louisville, Kentucky

CY2383-1H

PRODUCTION SEQUENCE NUMBER (VIN POSITIONS 12 THROUGH 17)

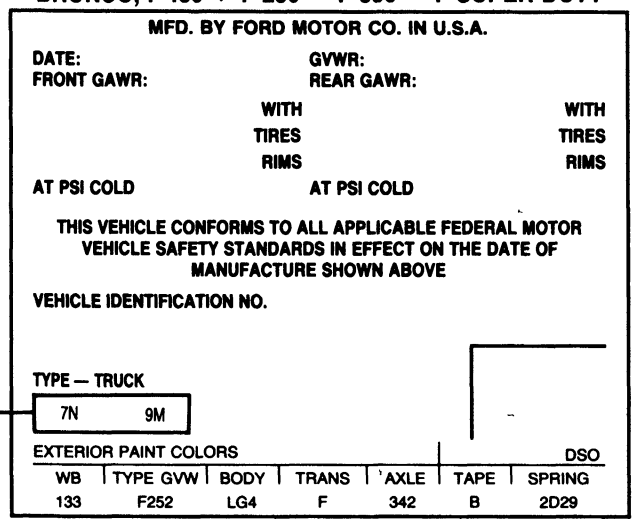
1 F T B F 2 5 G 5 K L [A 0 0 0 0 1]

SEQUENCE NUMBER
A 00001 — A 99,000
B 00001 — B 99,999
and so on.

CY2384-1H

DAVE GRAHAM INC. 2012
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EXTERIOR PAINT COLOR CODES
BRONCO, F-150 — F-250 — F-350 — F-SUPER DUTY



BRONCO EXTERIOR PAINT COLOR CODES

Code	Color
1C	Black
1D	Smoke Metallic
1G	Light Smoke Metallic
2D	Medium Scarlet
2H	Medium Cabernet
7H	Bright Regatta Blue Metallic
7N	Dark Shadow Blue Metallic
9M	White
9N	Desert Tan Metallic
9T	Light Chestnut
42	Alpine Green Metallic
95	Dark Chestnut Metallic
99	Prime
Fiberglass Roof Colors	
A	Black
B	Blue
H	Desert Tan
W	White

NOTE — TWO SETS OF CODES INDICATE TWO-TONE PAINT

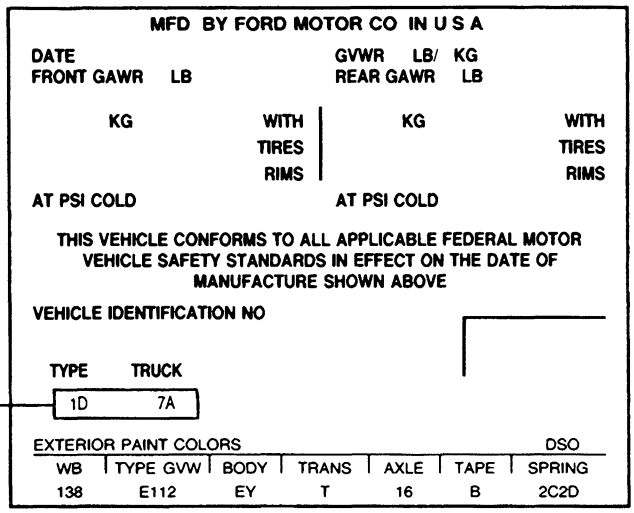
F-150 — F-350 AND F-SUPER DUTY EXTERIOR PAINT COLOR CODES

Code	Color
1C	Black
1D	Smoke Metallic
1G	Light Smoke Metallic
2D	Medium Scarlet
2H	Medium Cabernet
7H	Bright Regatta Blue Metallic
7N	Dark Shadow Blue Metallic
9M	White
9N	Desert Tan Metallic
9T	Light Chestnut
42	Alpine Green Metallic
95	Dark Chestnut Metallic
99	Prime

CY2668-2F

DAVE GRAHAM INC. 2012
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EXTERIOR PAINT COLOR CODES
E-150 — E-250 — E-350



E-150 — E-350

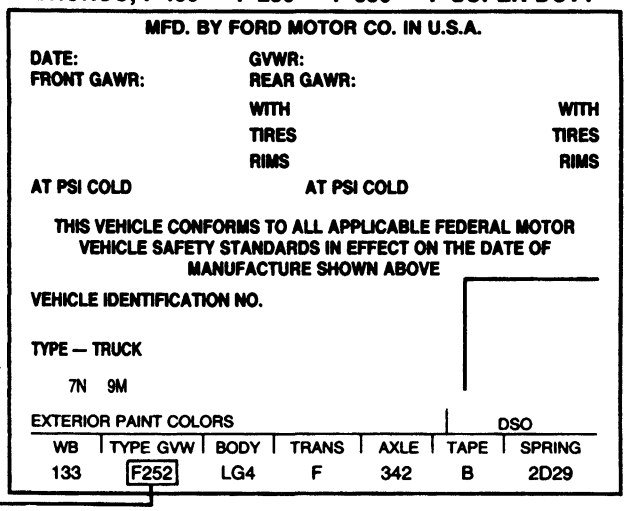
Code	Color
1D	Smoke Metallic
1G	Light Smoke Metallic
3R	Medium Shadow Blue Metallic
7A	Spinnaker Blue
7N	Dark Shadow Blue Metallic
9M	White
9N	Desert Tan Metallic
9T	Light Chestnut
27	Medium Red
95	Dark Chestnut Metallic
99	Prime

NOTE: Two sets of codes indicate two-tone paint

CY2794-2D

DAVE GRAHAM INC. 2012
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TYPE — GROSS VEHICLE WEIGHT (GVW) CODES
BRONCO, F-150 — F-250 — F-350 — F-SUPER DUTY



F25 | 2

Series	Series Code	GVWR Code	GVWR (lb.)	Wheelbase (in.)
Bronco				
U150	U15	2	6050	105
	U15	4	6300	105
	U15	5	6450	105

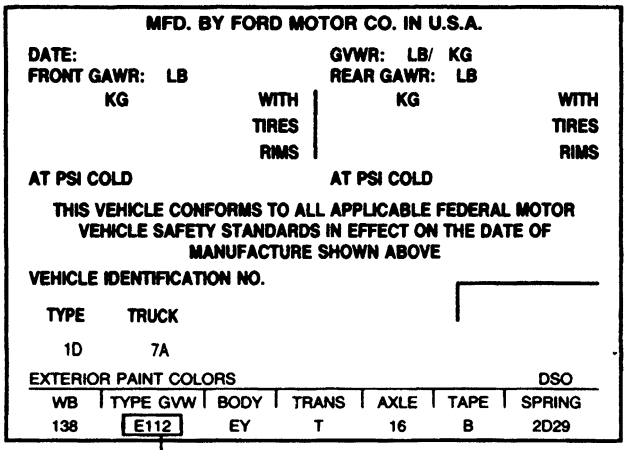
F-150 — F-250 — F-350				
F-150 (4x2)	F15	3	5250	117
	F15	4	5450	133
	F15	5	6250	133
	X15	1	6050	139
	X15	2	6250	155
F-150 (4x4)	F14	1	6100	117
	F14	2	6250	133
	X14	3	6250	139
	X14	1	6250	155
F-250 (4x2) Light Duty	F25	1	6600	133
	F25	2	7700	133
F-250 (4x2) Heavy Duty	F25	7	8600	133
	X25	9	8800	155

Series	Series Code	GVWR Code	GVWR (lb.)	Wheelbase (in.)
F-250 (4x4)	F26	1	6800	133
	X26	8	8800	155
	F26	8	8600	133
F-350 (4x2)	F35	2	10,000	133
	F37	4	8800	133
	F37	8	10,000	137, 161
	F37	9	11,000	137, 161
	W35	2	9200	168
	W35	3	10,000	168
	X35	1	10,000	155
F-350 (4x4)	F36	1	9000	133
	F38	2	8800	133
	F38	4	11,000	137, 161
	W36	1	9200	168
F-Super Duty (4x2)	F47	6	14,500	137, 161
F-Super Duty Stripped Chassis	F59	1	16,000	158
F-Super Duty Motor Home Chassis	F53	1	16,000	178, 208

CY2669-2F

DAVE GRAHAM INC. 2012
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TYPE — GROSS VEHICLE WEIGHT (GVW) CODES
E-150 — E-250 — E-350



E-150 — E-350 CLUB — XL AND XLT WAGONS

Series	Series Code	GVWR Code	GVWR (lb.)
E-150 Conventional	E11	2	6,600
E-250 Conventional	E21	P	8,550
E-350 Super	S31	5	9,100

E-150 — E-350 CARGO VANS

Series	Series Code	GVWR Code	GVWR (lb.)
E-150 Conventional Cargo	E14	1	5,500
	E14	2	6,100
	E14	3	6,500
E-150 Super Cargo	S14	1	6,200
E-250 Conventional Cargo	E24	1	7,200
	E24	2	7,900
E-250 Super Cargo	S24	1	8,100
E-350 Conventional Cargo	E34	1	9,400
	E34	2	9,500
E-350 Super Cargo	S34	1	9,000

E-350 REGULAR CUTAWAY VANS

Series	Series Code	GVWR Code	GVWR (lb.)
E-350 Regular Cutaway Van	E30	2	10,500 DR
	E30	3	11,000 DR

SR: Single Rear Wheels
DR: Dual Rear Wheels

E-350 COMMERCIAL CUTAWAY VANS

Series	Series Code	GVWR Code	GVWR (lb.)
E-350 Commercial Cutaway Van	E37	1	10,000 DR
	E37	2	10,300 DR
	E37	3	10,700 DR

SR: Single Rear Wheels
DR: Dual Rear Wheels

E-350 STRIPPED CHASSIS VAN

Series	Series Code	GVWR Code	GVWR (lb.)
E-350 Stripped Chassis Van	E39	U	9,400 SR
	E39	W	10,000 DR

SR: Single Rear Wheels
DR: Dual Rear Wheels

E-350 COMMERCIAL CUTAWAY STRIPPED CHASSIS

Series	Series Code	GVWR Code	GVWR (lb.)
E-350 Commercial Cutaway Stripped Chassis	E33	3	11,500 DR

CY2779-2E

DAVE GRAHAM INC. 2012
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BODY CODES
BRONCO, LIGHT TRUCK,
(F-150 — F-250 — F-350 — F-SUPER DUTY)

MFD. BY FORD MOTOR CO. IN U.S.A.

DATE: GVWR:
FRONT GAWR: REAR GAWR:

	WITH TIRES RIMS	WITH TIRES RIMS
	AT PSI COLD	AT PSI COLD

THIS VEHICLE CONFORMS TO ALL APPLICABLE FEDERAL MOTOR VEHICLE SAFETY STANDARDS IN EFFECT ON THE DATE OF MANUFACTURE SHOWN ABOVE

VEHICLE IDENTIFICATION NO.

TYPE — TRUCK
1D 7A

EXTERIOR PAINT COLORS

WB	TYPE GVW	BODY	TRANS	AXLE	TAPE	DSO SPRING
133	F252	LG4	F	342	B	2D29

L	J	4

LIGHT TRUCK

Code	Fabric	Seat Type
B	Vinyl	Bench
D	Knit & Vinyl	Bench
L	Bodycloth	Bench
R	Cloth	Captains Chair
S	Cloth	Bench
T	Bodycloth	Flight Bench

BRONCO

Code	Fabric	Seat Type
A	Vinyl	Bucket
L	Cloth	Bench
M	Cloth	Bucket
H	Bodycloth	Captains Chair
R	Cloth	Captains Chair

BRONCO AND F-SERIES

Trim Color	
Code	Color
B	Regatta Blue
D	Canyon Red
J	Granite
K	Chestnut

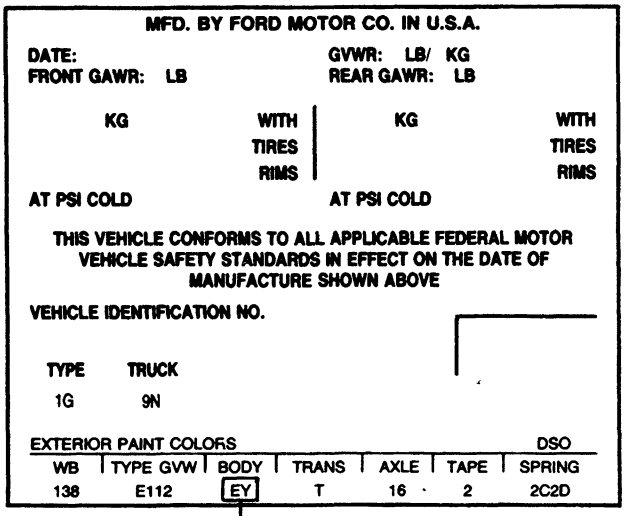
F-SERIES ONLY
CAB/BACK OF CAB

Super Cab	Crew Cab	Regular	Specifications
M	D	4	Styleside Pickup
		8	Chassis Cab
		X	Stripped Chassis (Mexico)

CY2388-2H

DAVE GRAHAM INC. 2012
ALL RIGHTS RESERVED

BODY CODES
E-150 — E-250 — E-350



SEAT TRIM AND STYLE

Code	Trim	Type
A	Vinyl	Bucket
E	Vinyl	Bucket
K	Cloth	Bucket
L	Cloth	Captain Chairs

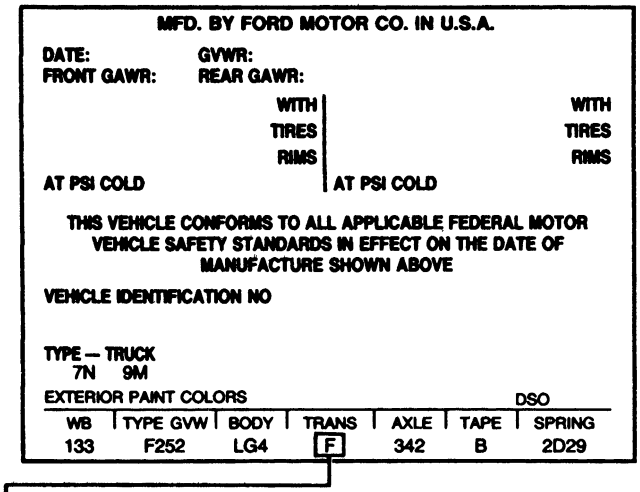
TRIM COLOR

Code	Color
B	Regatta Blue
D	Canyon Red
J	Granite
K	Chestnut

CY2780-2E

DAVE GRAHAM INC. 2012
ALL RIGHTS RESERVED

TRANSMISSION CODES
BRONCO, E-150 — E-250 — E-350, F-150 — F-250 — F-350 — F-SUPER DUTY



Code	Description
BRONCO	
K	Automatic C6
T	Automatic — AOD
M	Manual — 5-Speed Overdrive (M5OD)
Z	Manual — 5-Speed H D Overdrive (M5OD-HD)
F	Manual — 4-Speed

E-150 — E-250 — E-350	
G	Automatic — C6
T	Automatic 4-Speed AOD
E	Automatic — E4OD
M	Manual — 5-Speed Overdrive (M5OD)
Z	Manual — 5-Speed H D Overdrive (M5OD-HD)

F-150 — F-250 — F-350	
K	Automatic — C6
T	Automatic — AOD
E	Automatic — E4OD
F	Manual — 4-Speed
C	Manual — 5-Speed Close Ratio
M	Manual — 5-Speed Overdrive (M5OD)
Z	Manual — 5-Speed H D Overdrive (M5OD-HD)

CY2390-2H

DAVE GRAHAM INC. 2012
ALL RIGHTS RESERVED

AXLE CODES
BRONCO, F-150 — F-250 — F-350 — F-SUPER DUTY

MFD. BY FORD MOTOR CO. IN U.S.A.

DATE: GVWR:
FRONT GAWR: REAR GAWR:

WITH TIRES RIMS AT PSI COLD

WITH TIRES RIMS AT PSI COLD

THIS VEHICLE CONFORMS TO ALL APPLICABLE FEDERAL MOTOR VEHICLE SAFETY STANDARDS IN EFFECT ON THE DATE OF MANUFACTURE SHOWN ABOVE

VEHICLE IDENTIFICATION NO.

TYPE-TRUCK
7N 9M

EXTERIOR PAINT COLORS

WB	TYPE GVW	BODY	TRANS	AXLE	TAPE	DSO SPRING
133	F252	LG4	F	252	B	2D29

25 | 2

REAR AXLE CODES

Code	Capacity (lbs.)	Ratio
12	3800	2 73
18	3800	3 08
19	3800	3.55
H5	3800	4.10
H8	3800	3.08
H9	3800	3.55
25	3800	4 10
27	5300	3.73
29	5300	3.55
B5	5300	4.10
B9	5300	3.55
35	6250	4.10
39	6250	3.55
C5	6250	4.10
C9	6250	3.55
45	7400	4.10
49	7400	3 55
D5	7400	4.10
65	8250	4.10
69	8250	3.55
F5	8250	4.10
72	11,000	4.63
73	11,000	5.13
W5	8250	4.00

FRONT AXLE CODES (Not Applicable On E-150 — E-250 — E-350)

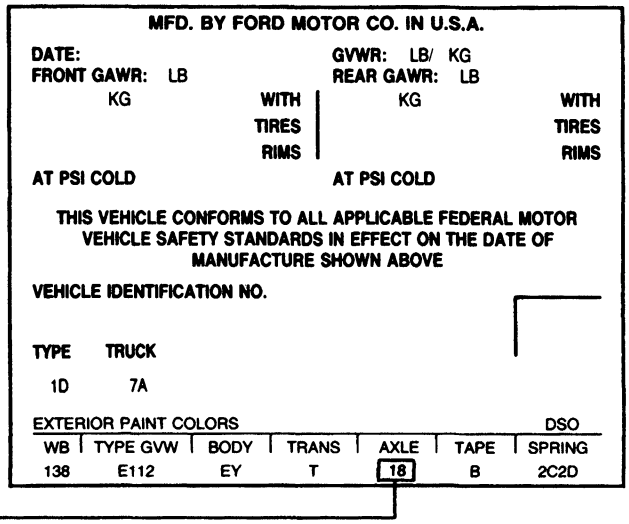
Bronco and F-150 — F-250 — F-350

Code	Description
2	Front Axle Limited Slip

CY2671-2F

DAVE GRAHAM INC. 2012
ALL RIGHTS RESERVED

AXLE CODES
E-150 — E-250 — E-350



E-150 — E-250 — E-350 REGULAR REAR AXLE

Code	# Capacity	Ratio
18	3800	3.08
19	3800	3.55
23	5300	3.54
24	5300	3.73
33	6340	3.54
52	7400	4.10
53	7400	3.54
32	6340	4.10

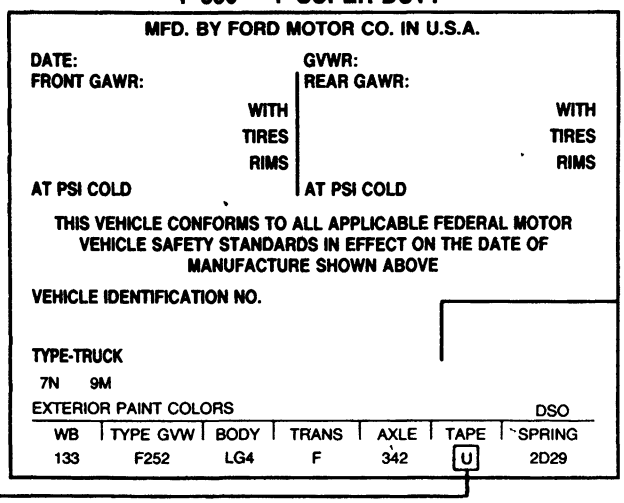
E-150 — E-250 — E-350 LIMITED SLIP REAR AXLE

Code	# Capacity	Ratio
H9	3750	3.08
B4	5300	3.73
C2	6340	4.10
C3	6340	3.54
E2	7400	4.10

CY2781-2D

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EXTERNAL BODY TAPE STRIPE CODES
BRONCO, E-150 — E-250 — E-350, F-150 — F-250 — F-350 — F-SUPER DUTY



BRONCO EXTERNAL TUTONE BODY TAPE STRIPE CODES

Code	Tape Stripe
1	Light Regatta Blue/Bright Regatta Blue
2	Light Chestnut Tan/Light Desert Tan
3	Medium Charcoal/Red Orange
U	Light Desert Tan — Paint Stripe with Medium Tan/Dark Tan — Tape Break Stripe

F-150 — F-350 EXTERNAL BODY TAPE STRIPE CODES
XL SRW STYLESIDE SOLID PAINT (PAINT STRIPE)
LESS CHAMFER STRIPES

Code	Tape Stripe
1	Red Orange
2	Grabber Blue
3	Copper
4	Light Desert Tan
5	Medium Gray

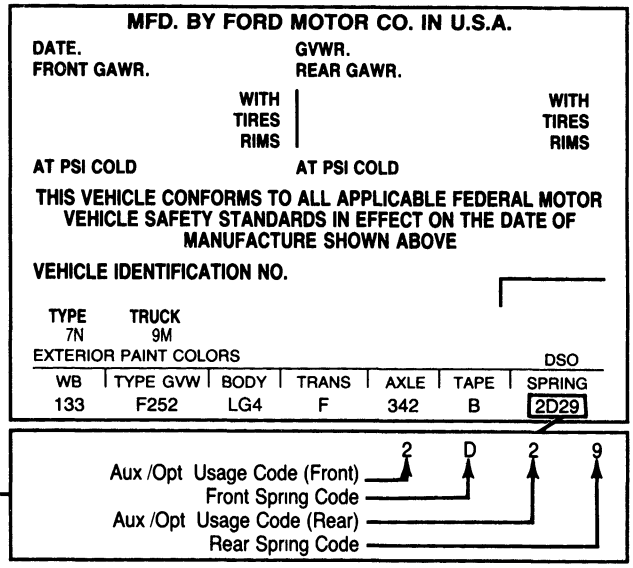
F-150 — F-350 ALL TUTONES (TAPE)
REGULAR AND VICTORIA TUTONES (TAPE)

Code	Tape Stripe
1	Light Regatta Blue/Bright Regatta Blue
2	Light Chestnut/Light Desert Tan
3	Medium Charcoal/Red Orange

CY2672-2F

DAVE GRAHAM INC. 2012
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SUSPENSION — SPRING IDENTIFICATION CODES
BRONCO, F-150 — F-250 — F-350 — F-SUPER DUTY



BRONCO SPRING IDENTIFICATION CODES

Aux./Opt. Usage Code (Front) — Not Applicable **Aux./Opt. Usage Code (Rear) — Not Applicable**

FRONT SPRING CODES — BRONCO

Code	Part Number
B	E0TA-5310-BC
C	E0TA-5310-CC
G	E0TA-5310-GC
U	E0TA-5310-UC
V	E0TA-5310-VB

REAR SPRING CODES — BRONCO

Code	Part Number
Z	E3TA-5560-ANA

F-150 — F-250 — F-350 — F-SUPER DUTY AUX./OPT. FRONT SPRING USAGE CODE

Code	Description
3	Maximum Front GAWR Package
4	Heavy Duty Front Suspension Package

F-150 — F-250 — F-350 — F-SUPER DUTY FRONT SPRING CODES

Code	Part Number
A	E0TA-5310-AC
B	E0TA-5310-BC
C	E0TA-5310-CC
D	E0TA-5310-DC
E	E0TA-5310-EC
F	E0TA-5310-FC
G	E0TA-5310-GC
H	E3TA-5310-XA
J	E3TA-5310-YA
K	E3TA-5310-ZA
M	E3TA-5310-AAA
N	E5TS-5310-BA
R	E5TA-5310-RA
S	E5TA-5310-SA
T	E5TA-5310-TA
U	E0TA-5310-UC
V	E0TA-5310-VB
1	E8TA-5310-AA
2	E9TD-5310-BB
3	E9TD-5310-AD
5	E0TA-5310-AAB
6	E0TA-5310-ABB
7	E0TA-5310-ACB
8	E5TA-5310-NA
9	E3TA-5310-ABA

F-150 — F-250 — F-350 — F-SUPER DUTY AUX./OPT. REAR SPRING USAGE CODE

Code	Description
3	Heavy Duty Rear Suspension Package
—	Auxiliary Rear Springs
4	400# — F-150
7	710# — F-250 — F-350
9	900# — F-350 — F-Super Duty
X	F53 — F59

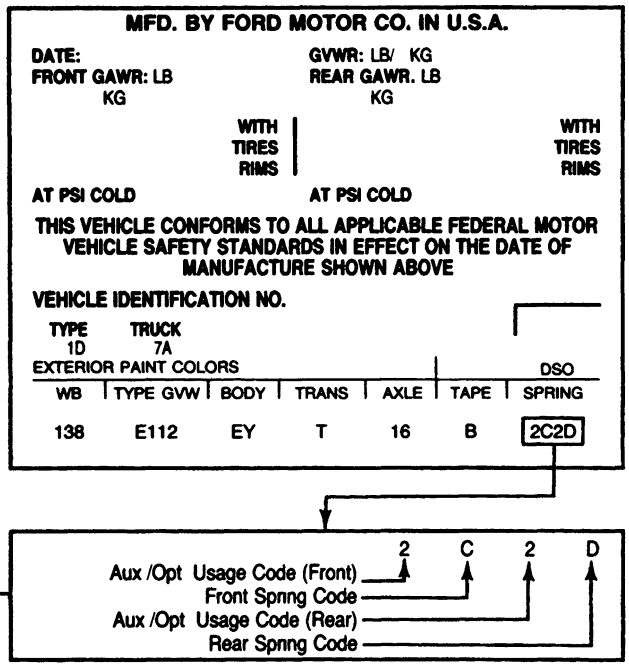
F-150 — F-250 — F-350 — F-SUPER DUTY REAR SPRING CODE

Code	Part Number
A	E4TA-5560-SA
D	E6TA-5560-NA
F	E7TA-5560-FA
L	E3TA-5560-KA
V	E6TA-5560-RA
Y	E7TA-5560-YA
2	E9TD-5560-BD
3	E9TD-5560-CA
4	E9TD-5560-AD
6	E4TA-5560-EA
7	E7TA-5560-KA
8	E8TA-5A975-AA
9	E4TA-5560-HA

CY2673-2E

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SUSPENSION-SPRING IDENTIFICATION CODES
E-150 — E-250 — E-350



E-150 — E-250 — E350
AUX./OPT. FRONT SPRING USAGE CODE

Code	Description
2	Heavy Duty Front Springs
4	Front Spring 3,850/4,200 # GAWR Rating

E-150 — E-250 — E350
FRONT SPRING CODES

Code	Part Number
F	D5UA-5310-HB
G	D5UA-5310-JB
H	D5UA-5310-KA
J	D5UA-5310-LB
K	D5UA-5310-MA
L	D5UA-5310-RA
M	D5UA-5310-SA
N	D5UA-5310-UA
O	D5UA-5310-VA
P	D5UA-5310-ALB
R	D5UA-5310-AMB
S	D5UA-5310-ARB
T	D5UA-5310-AUB
Y	D8TA-5310-HA
1	E7UA-XA
2	E7UA-YA
3	E7UA-ZA
4	E7UA-AAA
5	E7UA-BAA
6	E7UA-CAA
7	E7UA-DAA
X	E6US-AA

E-150 — E-250 — E-350
AUX./OPT. REAR SPRING USAGE CODES

Code	Description
2	Heavy Duty Rear Springs
4	Handling Package

E-150 — E-250 — E-350
REAR SPRING CODES

Code	Part Number
A	D9TA-5560-ZA
C	E1TA-5560-ACA
F	E1TA-5560-ALA
J	D9TA-5560-LA
K	D9TA-5560-HA
L	E2TA-5560-ARA
M	E1TA-5560-AGA
N	E1TA-5560-AHA
P	D9TA-5560-AYA
Q	E0TA-5560-BVA
T	D9TA-5560-KA
W	E4UA-5560-RA
Y	D9TA-5560-AVA
Z	D9TA-5560-JA

CY2782-2E

DAVE GRAHAM INC. 2012
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DISTRICT SALES OFFICE (DSO) AND WHEELBASE (WB) CODES BRONCO, E-150 — E-250 — E-350, F-150 — F-250 — F-350 — F-SUPER DUTY

MFD. BY FORD MOTOR CO. IN U.S.A.

DATE: GVWR:
FRONT GAWR: REAR GAWR:
WITH TIRES RIMS AT PSI COLD
WITH TIRES RIMS AT PSI COLD

THIS VEHICLE CONFORMS TO ALL APPLICABLE FEDERAL MOTOR VEHICLE SAFETY STANDARDS IN EFFECT ON THE DATE OF MANUFACTURE SHOWN ABOVE

VEHICLE IDENTIFICATION NO.

TYPE-TRUCK
7N 9M

21

EXTERIOR PAINT COLORS

DSO

WB	TYPE GVW	BODY	TRANS	AXLE	TAPE	SPRING
133	F252	LG4	F	342	B	2D29

DSO — FSO — PTO (DOMESTIC, FOREIGN AND SPECIAL ORDER)

The D.S.O. space will show a two-digit code number of the district which ordered the unit (see chart below). This code will appear on all units — domestic or export. If unit is built on a D.S.O., F.S.O., P.T.O. (special orders), the complete order number is under the D.S.O. spacer **after** the district code number.

Wheelbase (inches)

Bronco
105

F-150 — F-250 — F-350		F-Super Duty
117		137
133	155	161
137	161	158
139	168	178
		208

E-150 — E-250 — E-350 (Econoline and Club Wagon)
124
138
158
176

Code	District
11	Boston
12	Buffalo
13	New York
14	Pittsburgh
16	Philadelphia
17	Washington
21	Atlanta
22	Charlotte
23	Memphis
24	Jacksonville
26	New Orleans
28	Louisville
41	Chicago
42	Cleveland
43	Milwaukee
46	Indianapolis
47	Cincinnati
48	Detroit

Code	District
52	Dallas
53	Kansas City
54	Omaha
55	St. Louis
57	Houston
58	Twin Cities
71	Los Angeles
72	San Jose
74	Seattle
75	Phoenix
76	Denver
83	Government
84	Home Office Reserve
85	American Red Cross
86	Recreation Vehicles
87	Body Company
89	Transportation Services
90's	Export
00	Special

Ford of Canada	
Mercury Regions	**Ford Regions**
A1 Central	B1 Central
A2 Eastern	B2 Eastern
A3 Atlantic	B3 Atlantic
A4 Midwestern	B4 Midwestern
A6 Western	B6 Western
A7 Pacific	B7 Pacific
A8 Great Lakes	B8 Great Lakes
11 Export	11 Export

CY2392-2H

DAVE GRAHAM INC. 2012
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GROUP

GASOLINE ENGINES 21

(6000 & 9000)

SECTION TITLE	PAGE
GENERAL GASOLINE ENGINE SERVICE	21-01-1
4.9L (300 CID) SIX-CYLINDER ENGINE	21-11-1
5.0L EFI (302 CID) V-8 AND 5.8L EFI (351 CID) W-V-8 ENGINES	21-21-1
7.5L (460 CID) EFI V-8 ENGINES	21-24-1

SECTION 21-01 General Gasoline Engine Service

SUBJECT	PAGE
CLEANING AND INSPECTION	
Camshaft	21-01-20
Connecting Rods	21-01-22
Crankcase Ventilation System	21-01-18
Crankshaft	21-01-21
Crankshaft Vibration Damper and Sleeve	21-01-21
Cylinder Block	21-01-23
Cylinder Heads	21-01-18
Cylinder Head Flatness	21-01-18
Exhaust Manifolds	21-01-20
Flywheel	21-01-21
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VEHICLE APPLICATION

All Light Truck Vehicles.

DESCRIPTION

All gasoline engines covered in this manual incorporate positive closed-type crankcase ventilation systems and appropriate exhaust emission controls. The emission control systems are covered in detail in the Engine/Emissions Diagnosis* manual and in Section 10-02, Maintenance.

This Section covers tests, adjustments, repair procedures, cleaning and inspections common to most gasoline engines. When performing tests, adjustments, and repairs, it is essential to follow the procedures and specifications provided. Specifications are listed at the end of each pertinent engine section.

Emission Calibration Label

Refer to Fig. 1.

The emission calibration number label is located on the LH side door or LH door post pillar. It identifies the engine calibration number, the engine code number and revision level.

These numbers are used to determine if parts are unique to specific engines.

NOTE: It is imperative that the engine codes and the calibration number be used when ordering parts or making inquiries about the engine.

Vehicle and Engine Identification

Vehicle identification, the location of the vehicle rating and data plates and engine code information is fully covered in Section 20-00, Identification Codes. For specific and exact engine identification, a decal label (Fig. 2) is located on the door post pillar near the VIN number. On vehicles over 6000 GVWR the label is on the same engine component as the Vehicle Emission Certification Information (VECI) Decal. Refer to Fig. 38.

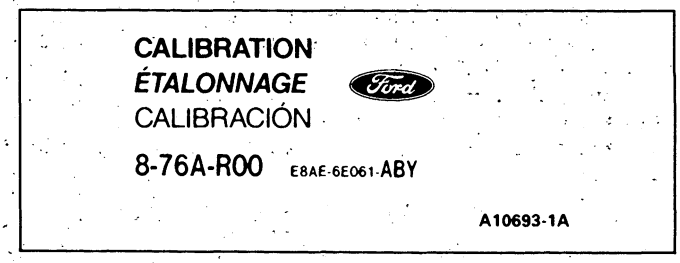


FIG. 1 Emission Calibration Label

Always refer to this label when replacement parts are required or when checking engine calibrations. Engine parts often differ within a CID family. Verification of identification codes will ensure that the proper parts are obtained. The codes contain all pertinent information relating to dates, optional equipment and revisions. The Ford Master Parts Catalog contains a complete listing of the codes and their application.

LUBRICATION

Gasoline Engines

General

By law, vehicles are equipped with air pollution control systems. To maintain these systems, use of a high quality motor oil is essential. Motorcraft Motor Oil or equivalent oils are formulated to meet these requirements. Other brands, if used, must meet Ford performance specification ESE-M2C153-D (API Category SG).

Motor oils formulated for API service SG provide increased oxidation stability and improved anti-wear performance relative to oils which meet the minimum requirements for API service category SE. These oils also provide protection against engine deposits, rust and corrosion. Oils meeting API service Category SG may be used where API Service Categories SE, SD or SC are recommended.

Refer to Section 10-02, Maintenance for engine oil and oil filter change recommended maintenance schedule.

Oil Viscosity

Select the viscosity that most nearly matches the expected temperature range of vehicle operation. Refer to Specifications.

Oil Filter

Proper oil filtration is as essential as good motor oil. The two-stage filtering action of a Motorcraft oil filter has been shown by tests to be more effective than ordinary filters. Use Motorcraft oil filters or one which meets the Ford specifications (Section 50-03 Lubrication Charts and Lubricant Specifications).

Check Engine Oil Level

Use the dipstick to check the oil level; it should be between the ADD and FULL marks on the dipstick or within the SAFE area on the dipstick (if so equipped).

*Can be purchased as a separate item.

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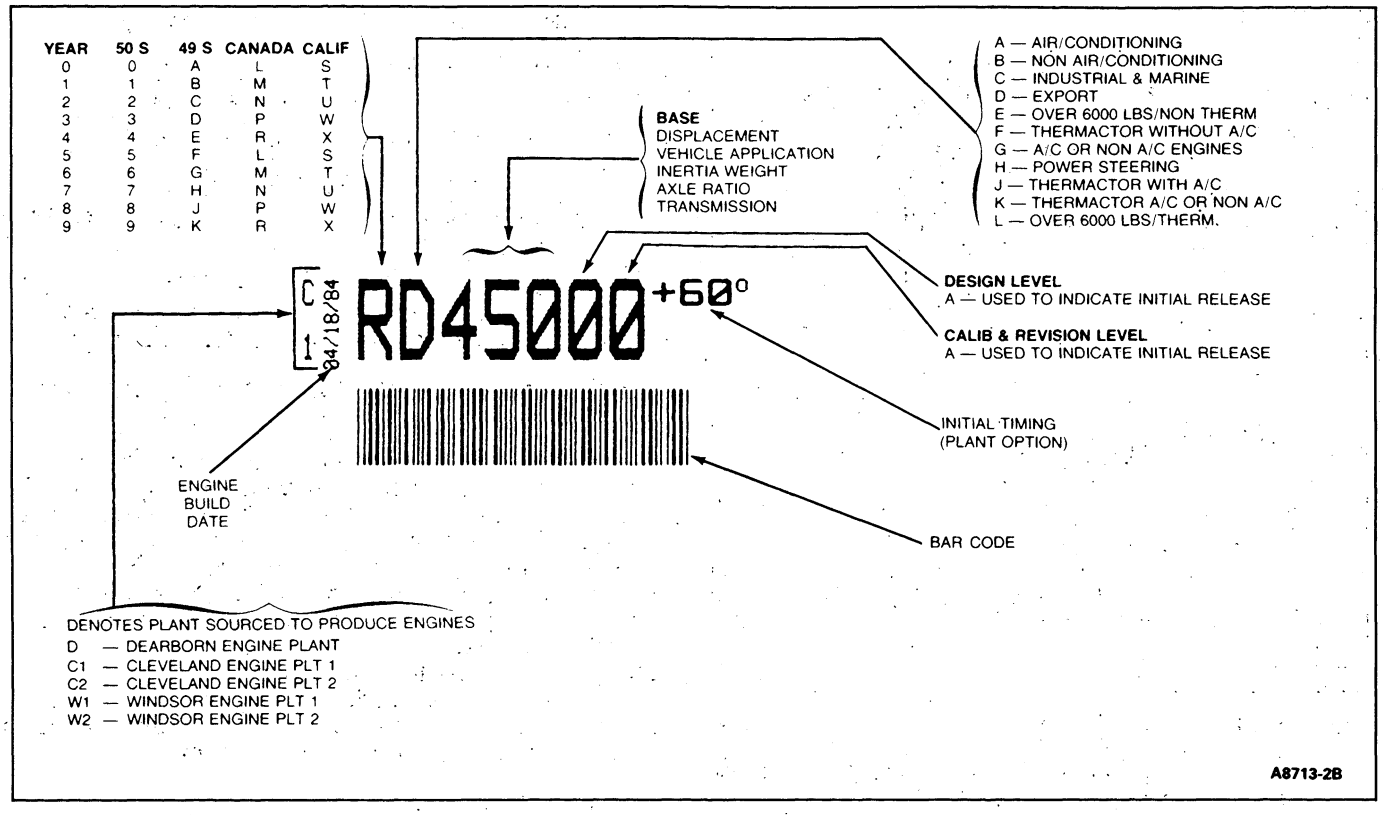


FIG. 2 Engine Identification

Add oil of specified quality only. Refer to Pre-Delivery manual Section 50-03, Lubrication Charts and Lubricant Specifications.

Engine Oil Change

1. Apply parking brake and block wheels.
2. Bring engine to normal operating temperature and turn off.
3. Remove oil drain plug and drain engine oil.
4. Clean oil drain plug and inspect gasket. Replace gasket if damaged.
5. Verify that gasket is properly located. Correct as required.
6. Install oil drain plug and tighten to specification.

NOTE: If the oil filter is not to be changed, remove the oil filler cap and fill the crankcase with the specified amount, type and grade of oil.

Install the oil filler cap. Start the engine and inspect for oil leak(s). Correct as required.

Engine Oil Filter Change

1. Disposable-type oil filter change:
   - A. Remove oil filter and discard.
   - B. Clean the gasket sealing surface at the cylinder block or adapter.
   - C. Coat the gasket on the filter with a light film of oil. Screw the filter onto the adapter or cylinder block until the gasket contacts the sealing surface; then, advance it an additional 1/2 turn.

Remove the oil filler cap and fill the crankcase with the specified amount (refer to specifications), type, and grade of oil.

Install the oil filler cap. Start the engine and inspect for oil leak(s). Correct as required.

Check Engine Mountings

Occasionally, the engine mountings should be visually checked. If the vehicle is operated on rough terrain, this check should be made frequently. If the mounting bolts are loose, tighten them to specifications, refer to appropriate engine Section. If the insulators are cracked or frayed, replace them.

DIAGNOSIS AND TESTING

Engine Oil Leaks

When diagnosing engine oil leaks, it is important that the source of the leak be positively identified before any repairs are made. The following procedure has been found to be very effective.

To perform oil leak diagnosis, use Rotunda Leak Tester 112-00001 and Gas Engine Oil Dye 112-00005 or equivalent (Fig. 3).

1. Clean engine with a suitable solvent to remove all traces of oil.
2. Drain engine oil crankcase and refill with recommended oil pre-mixed with Fluorescent Oil Additive 112-00005. Use a minimum 14ml (1/2 fluid ounce) to a maximum 29.57ml (one fluid ounce) of fluorescent additive to all engines. If oil is not pre-mixed, fluorescent additive must be added to crankcase first.
3. Run engine for 30 minutes with occasional increase in RPM to raise oil pressure. Stop engine and inspect all seal and gasket areas for leaks using Rotunda Blacklight Oil Leak Detector 112-

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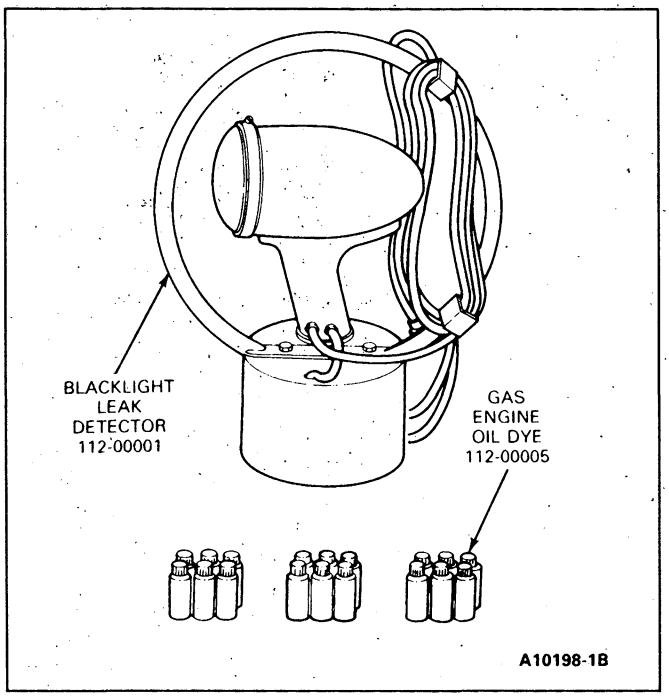


FIG. 3 Blacklight Leak Detector

00001 or equivalent. A clear bright yellow or orange area will identify leak.

4. If necessary, pressurize main oil gallery system to locate leaks due to improperly sealed, loose or cocked plugs. If flywheel bolts leak oil, look for sealer on threads.
5. Service all leaks as required.

Inspect the following areas for oil leakage:

Under Hood

a. Rocker cover gasket.
b. Cylinder front cover gasket.
c. Intake manifold gaskets.
d. Front and rear intake manifold end seals.
e. Cylinder head gasket.
f. Rubber grommets.
g. Fuel pump seal and/or mounting gasket.
h. Distributor O-ring.
i. Oil level indicator (dipstick) tube connection.
j. Oil pressure sending unit.
k. Cup plugs and/or pipe plugs at the end of oil passages.

Under Engine—With Vehicle on Hoist

a. Oil pan gasket.
b. Front and rear oil pan end seals.
c. Cylinder front cover gasket.
d. Front crankshaft seal.
e. Oil filter seal and/or adapter gasket.
f. Oil cooler mounting gasket and/or cover plate gasket.

With Transmission and Flywheel Removed

a. Rear crankshaft seal.
b. Rear main bearing cap parting line.
c. Rear main bearing cap end seals.
d. Flywheel mounting bolt holes.
e. Rear cup plugs and/or pipe plugs at the end of oil passages.

Oil leaks at crimped seams in sheet metal parts and cracks in cast or stamped parts can be detected when pressurizing the crankcase.

Positive Closed-Type Crankcase Ventilation System

A malfunctioning closed crankcase ventilation system may be indicated by a loping or rough engine idle. Do not attempt to compensate for this idle condition by disconnecting the crankcase ventilation system and making carburetor adjustments. **Removal of the crankcase ventilation system from the engine will adversely affect the fuel economy and engine ventilation resulting in shorter engine life.** To determine whether the loping or rough idle condition is caused by a malfunctioning crankcase ventilation system, refer to Emission System testing and diagnosis in the Engine/Emissions Diagnosis* manual.

Compression Test

Perform the following procedure on all engines when checking compression:

1. Ensure the crankcase oil is of the correct viscosity. Ensure that the battery is fully charged. Operate the engine for a minimum of 30 minutes at 1200 rpm, or until the engine is at normal operating temperature. Turn the ignition switch to OFF, then remove all spark plugs.
2. Set the throttle body (5.0L and 4.9L EFI) plates in the wide-open position.
3. Install a compression gauge into the No. 1 cylinder.
4. Crank the engine (with the ignition switch OFF) at least five pumping strokes and record the highest reading indicated. Note the approximate number of compression strokes required to obtain the highest reading.
5. Repeat the check on each cylinder cranking the engine approximately the same number of compression strokes.

Test Conclusion

The indicated compression pressures are considered normal if the lowest reading cylinder is within 75 percent of the highest. Refer to the quick reference chart (Fig. 4) for pressure limits between cylinders. Variations exceeding 75 percent imply an improperly seated valve or worn or broken piston rings. If one cylinder reads low, squirt approximately one tablespoon of engine oil on top of the pistons in the low reading cylinders. Repeat compression pressure check on these cylinders.

a. If compression improves considerably, the piston rings are at fault.
b. If compression does not improve, valves are sticking or seating poorly.

*Can be purchased as a separate item.

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Maximum kPa (PSI)	Minimum kPa (PSI)	Maximum kPa (PSI)	Minimum kPa (PSI)	Maximum kPa (PSI)	Minimum kPa (PSI)
923 (134)	697 (101)	1199 (174)	903 (131)	1475 (214)	1103 (160)
937 (136)	703 (102)	1213 (176)	910 (132)	1489 (216)	1116 (162)
951 (138)	717 (104)	1227 (178)	917 (133)	1503 (218)	1123 (163)
965 (140)	723 (105)	1241 (180)	930 (135)	1516 (220)	1137 (165)
979 (142)	737 (107)	1254 (182)	937 (136)	1530 (222)	1144 (166)
992 (144)	744 (108)	1268 (184)	951 (138)	1544 (224)	1158 (168)
1006 (146)	758 (110)	1282 (186)	965 (140)	1558 (226)	1165 (169)
1020 (148)	765 (111)	1296 (188)	972 (141)	1572 (228)	1179 (171)
1034 (150)	779 (113)	1310 (190)	979 (142)	1585 (230)	1185 (172)
1048 (152)	786 (114)	1323 (192)	992 (144)	1599 (232)	1199 (174)
1061 (154)	792 (115)	1337 (194)	999 (145)	1613 (234)	1206 (175)
1075 (156)	806 (117)	1351 (196)	1013 (147)	1627 (236)	1220 (177)
1089 (158)	813 (118)	1365 (198)	1020 (148)	1641 (238)	1227 (178)
1103 (160)	827 (120)	1379 (200)	1034 (150)	1654 (240)	1241 (180)
1116 (162)	834 (121)	1392 (202)	1041 (151)	1668 (242)	1247 (181)
1130 (164)	848 (123)	1406 (204)	1054 (153)	1682 (244)	1261 (183)
1144 (166)	854 (124)	1420 (206)	1061 (154)	1696 (246)	1268 (184)
1158 (168)	868 (126)	1434 (208)	1075 (156)	1709 (248)	1282 (186)
1172 (170)	875 (127)	1447 (210)	1082 (157)	1723 (250)	1289 (187)
1185 (172)	889 (129)	1461 (212)	1089 (158)		

CA1005-2B

FIG. 4 Quick Reference Compression Pressure Limit Chart

c. If two adjacent cylinders indicate low compression pressures and squirting oil on the pistons does not increase the compression, the cause may be a cylinder head gasket leak between the cylinders. Engine oil and/or coolant in the cylinders could result from this problem.

Example

After checking the compression pressures in all cylinders, the highest reading obtained was 965 kPa (140 psi) and the lowest pressure reading was 689 kPa (100 psi). By locating 965 (140) in the Maximum column it is seen that the lowest allowable pressure listed in the Minimum column is 723 kPa (105 psi). Since the lowest cylinder reading was 689 kPa (100 psi), the engine is not within specifications and the compression is not considered satisfactory.

Hydraulic Valve Tappet

Hydraulic tappet noise may be caused by any of the following:

1. Excessive collapsed tappet gap.
2. Sticking tappet plunger.
3. Tappet check valve not functioning properly.
4. Air in lubrication system.
5. Leakdown rate too rapid.
6. Excessive valve guide wear.

Excessive tappet gap may be caused by loose rocker arm fulcrum bolts, incorrect initial adjustment, or wear of tappet face, push rod, rocker arm, rocker arm fulcrum or valve tip. With tappet collapsed, check gap between valve tip and rocker arm to determine if any other valve train parts are damaged, worn, or out of adjustment.

A sticking tappet plunger may be caused by dirt, chips, or varnish inside the tappet. Correct this condition by disassembling the tappet and removing the dirt, chips or varnish causing the condition.

A tappet check valve that is not functional may be caused by an obstruction (dirt or chips) preventing it from closing when the cam lobe is lifting the tappet, or it may be caused by a broken check valve spring.

Air bubbles in the lubrication system will prevent the tappet from supporting the valve spring load and may be caused by too high or too low an oil level in the oil pan, or by air being drawn into the system through a hole, crack, or leaking gasket on the oil pump pickup tube.

If the leakdown time is below the specified time for used tappets, noisy operation may result. If no other cause for noisy tappets can be found, the leakdown rate should be checked and any outside the specification should be replaced.

Assembled tappets can be tested with Hydraulic Tappet Leakdown Tester TOOL-6500-E or equivalent to check the leakdown rate. The leakdown rate specification is the time in seconds for the plunger to move a specified distance of its travel while under a 22.68 kg (50-lb) load. Test the tappets as follows:

1. Disassemble and clean the tappet to remove all traces of engine oil.

NOTE: Do not mix parts from different tappets. Parts are select-fitted and are not interchangeable.

Tappets cannot be checked with engine oil in them. Only the testing fluid can be used.

2. Place the tappet in the tester, with the plunger facing upward. Pour hydraulic tappet tester fluid into the cup until the tappet assembly is immersed. The fluid can be purchased from the manufacturer of the tester. Using kerosene or any other fluid will not provide an accurate test.
3. Place the 7.938mm (5/16-inch) steel ball provided with the tester into the plunger cap (Fig. 5).

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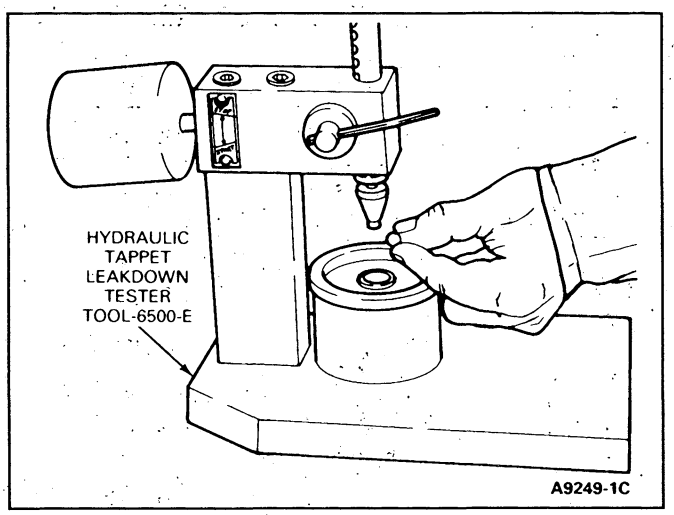


FIG. 5 Placing Steel Ball in Valve Tappet Plunger

4. Adjust the length of the ram (Fig. 6) so that the pointer is 1.588 (1/16 inch) below the starting mark when the ram contacts the tappet plunger. This adjustment will facilitate timing as the pointer passes the Start Timing mark.

   Use the center mark on the pointer scale as the Stop Timing point instead of the original Stop Timing mark at the top of the scale.
5. Work the tappet plunger up and down until the tappet fills with fluid and all traces of air bubbles have disappeared.
6. Allow the ram and weight to force the tappet plunger downward. Measure the exact time it takes for the pointer to travel from the Start Timing to the Stop Timing marks of the tester.
7. A tappet that is satisfactory must have a leakdown rate (time in seconds) within the minimum and maximum limits specified in the applicable engine Section.
8. If the tappet is not within specifications, replace it with a new tappet. It is not necessary to disassemble and clean new tappets before testing, because the oil contained in new tappets is test fluid.
9. Remove the fluid from the cup and bleed the fluid from the tappet by working the plunger up and down. This step will aid in depressing the tappet plungers when checking the valve clearance.

Static Engine Off Valve Train Analysis (Rocker Arm Cover Removed)

Rocker Arm Cover Removal

1. Remove air cleaner.
2. Disconnect and remove any hoses, wires, spark plug leads and components that would interfere with the removal of the rocker arm cover.
3. Remove the rocker arm cover bolts.
4. Remove the rocker arm cover.

Valve Train Analysis

Check for damaged and/or severely worn parts and for correct assembly. Ensure use of correct parts by proceeding, as follows, with the static engine analysis.

1. Rocker Arm Assemblies—Individually Mounted:

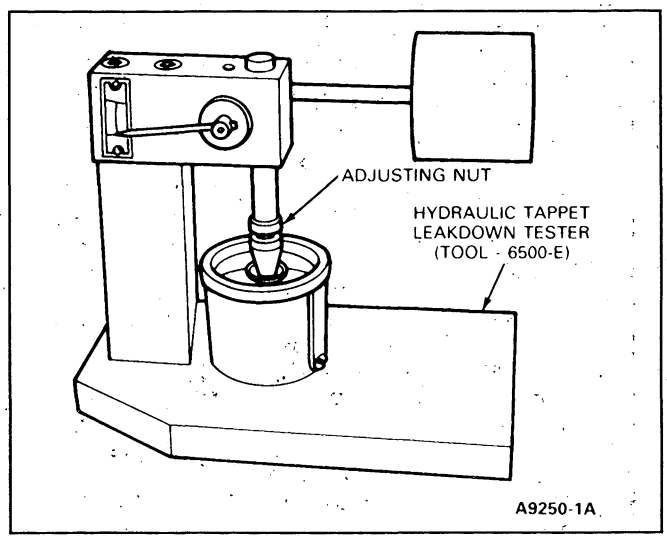


FIG. 6 Adjusting the Ram Length

   a. Check for loose mounting stud and nut or bolt.
   b. Check for plugged oil feed in the rocker arm.
2. Push Rods:

   Check for bent push rods.
3. Valve Spring Assembly—With or Without Damper Spring:

   Check for broken or damaged parts.
4. Retainer and Keys—Both two-piece and one-piece retainers:

   Check for proper seating of keys on valve stem and in retainer.
5. Positive Rotator and Keys:

   Check for proper seating of keys on valve stem in the positive rotator.
6. Valves and Cylinder Head
   a. Check the cylinder head gasket for proper installation.
   b. Check for plugged oil drain back holes.
   c. Check for worn or damaged valve tips.
   d. Check for missing or damaged valve stem oil seals.
   e. Check collapsed tappet gap—hydraulic tappet applications.
   f. Check installed spring height.
7. Overhead Cam Follower Arm and Lash Adjuster Assemblies:

   Check for broken or severely worn parts.

   Check for "soft" lash adjuster with hand pressure on rocker arm (arm on base circle of camshaft).
8. Camshaft—Overhead Camshaft Applications:
   a. Check for plugged oil feed.
   b. Check for correct cam lift.

      Static checks (engine off) are to be made on the engine prior to the following dynamic procedure.

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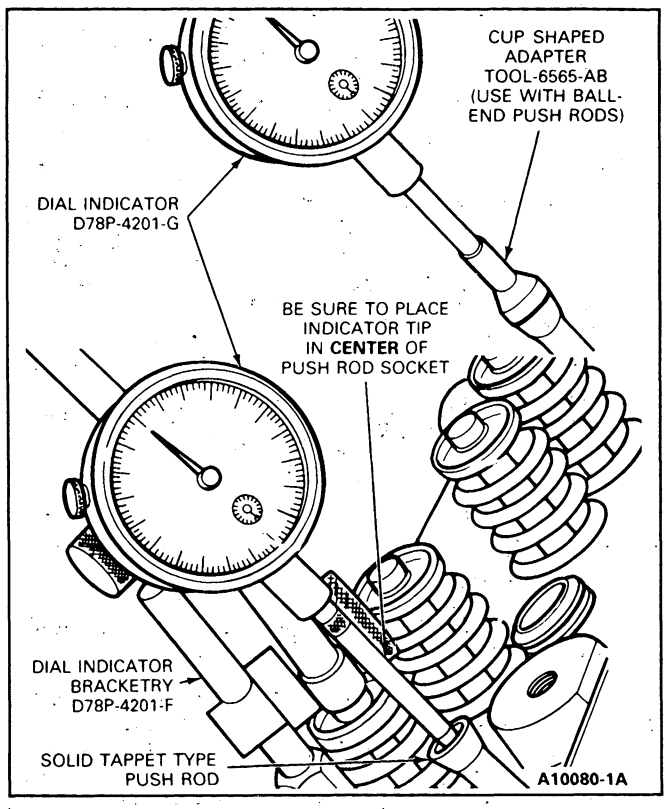


FIG. 7 Typical Camshaft Lobe Lift Hydraulic Tappet—V-8 Engines

Dynamic Valve Train Analysis

Valve Train Analysis

CAUTION: Do not perform dynamic analysis on overhead camshaft engines because of oil splash.

Start the engine and while running at idle check for proper operation of all parts. Check the following items:

1. Rocker Arm Assemblies—Individually Mounted:
   a. Check for plugged oil feed in rocker arm.

If insufficient oiling is suspected, accelerate the engine to 1200 RPM ±100 RPM with the transmission in NEUTRAL and the engine at normal operating temperature. Oil should spurt from the rocker arm oil holes, liberally oiling valve tips and rocker arms. With the rocker arm cover off, oil splash should overshoot rocker arm. If oiling is insufficient for this condition to occur, check oil passages for blockage.

2. Push Rods:
   a. Check for bent push rods.
   b. Check for proper rotation of push rods.
3. Positive Rotator and Keys:
   Check for proper operation of positive rotator.
4. Valves and Cylinder Head:
   a. Check for plugged oil drain back holes.
   b. Check for missing or damaged valve stem oil seals or for guide mounted oil seals.

Rocker Arm Cover Installation

1. Remove old gasket from cover. If necessary, scrape both the rocker arm cover rail on the cylinder head and the gasket flange on the cover to remove all traces of the old gasket.

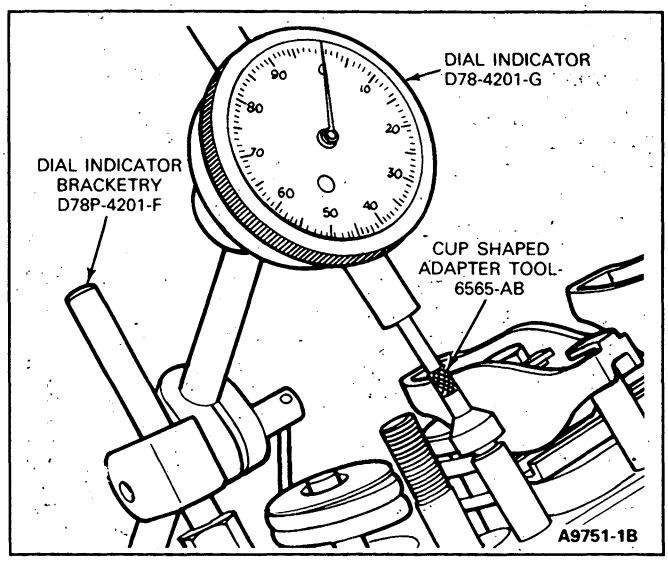


FIG. 8 Typical Camshaft Lobe Lift—4.9L (300 CID) I-6 Engines

2. Install a new gasket and replace the cover on the engine.
3. Install the rocker arm cover bolts. Tighten in sequence to specification in the specific engine Section in this manual.
4. Connect all hoses, wires, spark plug leads, and components.

Camshaft Lobe Lift

Check the lift of each lobe in consecutive order and make a note of the readings.

1. Remove the fresh air inlet tube and the air cleaner. Remove the heater hose and crankcase ventilation hoses. Remove valve rocker arm cover(s).
2. 4.9L uses Stamped Rocker arm (same as 5.0L). On 4.9L, 5.0L (302 CID) V-8, 5.8L (351 CID) W-V-8, and 7.5L (460 CID) V-8 engines, remove the fulcrum bolts, fulcrum seat and rocker arm.
3. Ensure the push rod is in the valve tappet socket. Install Dial Indicator D78P-4201-G or equivalent, and Dial Indicator Bracketry D78P-4201-F or equivalent, so that the actuating point of the indicator is in the push rod socket or the Cup Shaped Adapter TOOL-6565-AB or equivalent, is on the end of the push rod and in the same plane as the push rod movement (Fig. 7 or 8).
4. Disconnect the brown lead (I terminal) and the red and blue leads (S terminal) at the starter relay. Install an auxiliary starter switch between the battery and S terminals of the starter relay. Crank the engine with the ignition switch in OFF.
   Turn the crankshaft over until the tappet is on the base circle of the camshaft lobe. At this point, the push rod will be in its lowest position.
5. Zero the dial indicator. Continue to rotate the crankshaft slowly until the push rod is in the fully raised position.
6. Compare the total lift recorded on the indicator with specification listed in the specific engine Section.
7. To check the accuracy of the original indicator reading, continue to rotate the crankshaft until the

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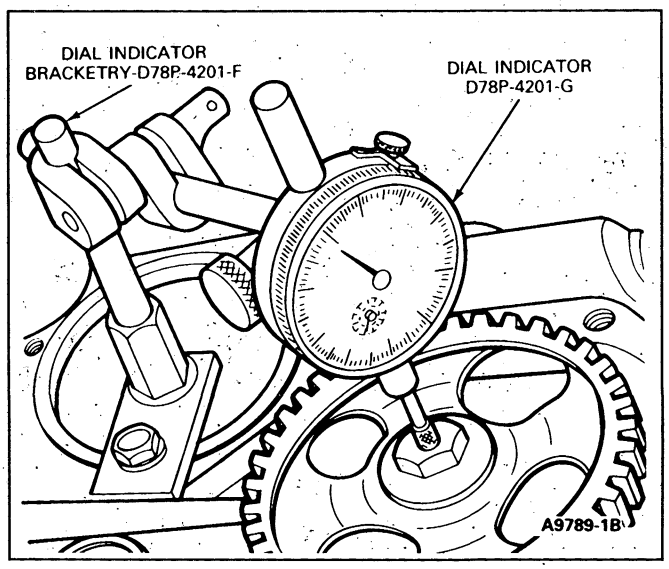


FIG. 9 Checking Camshaft End Play

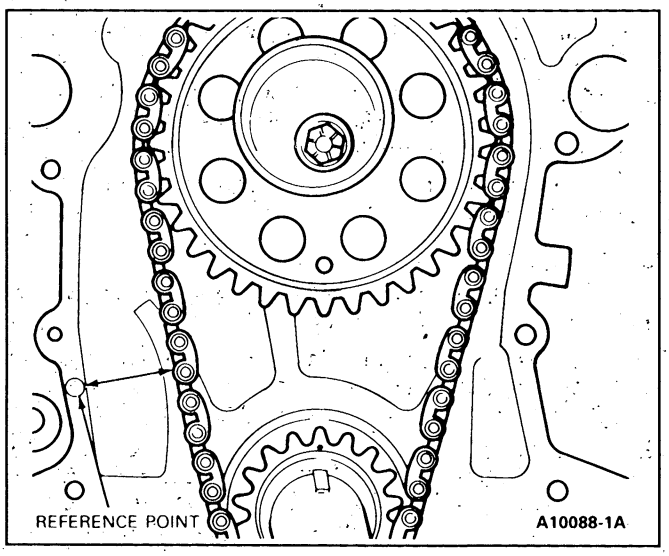


FIG. 10 Checking Timing Chain Deflection

indicator reads zero. If the lift on any lobe is below specified wear limits listed in the applicable engine section, the camshaft and the valve tappet operating on the worn lobe(s) must be replaced.

8. Remove the dial indicator and auxiliary starter switch.

   On 4.9L (300 CID) I-6, 5.0L (302 CID) V-8, 5.8L (351 CID) W-V-8, and 7.5L (460 CID) V-8, install the rocker arm, fulcrum seat and fulcrum bolts. Check the valve clearance. Refer to applicable engine section. Adjust if required, as outlined.

9. Install the valve rocker arm cover(s) and the air cleaner.

Camshaft End Play

On all 6 and 8 cylinder engines: prying against the camshaft sprocket with the valve train load on the camshaft can break or damage the sprocket. Therefore, the rocker arm adjusting nuts must be backed off, or the rocker arm and shaft assembly must be loosened sufficiently to free the camshaft. After checking the camshaft end play, check the valve clearance. Adjust if required, as outlined.

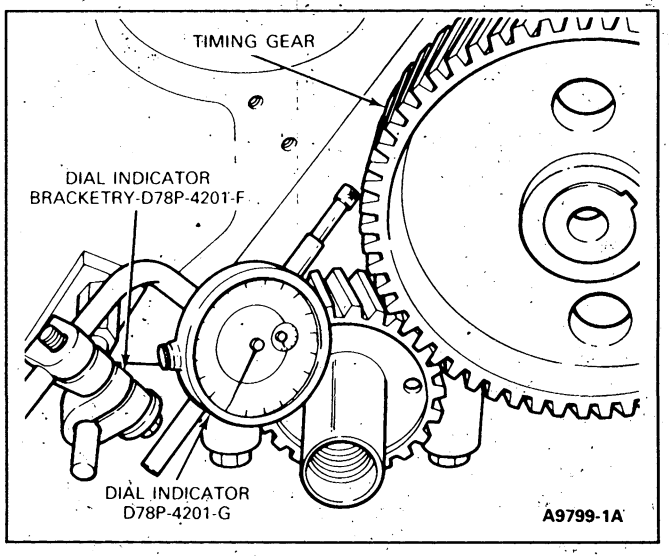


FIG. 11 Checking Timing Gear Backlash

Push the camshaft toward the rear of the engine. Install Dial Indicator D78P-4201-G or equivalent, and Dial Indicator Bracketry D78P-4201-F or equivalent, so that the indicator point bears on the camshaft sprocket attaching screw (Fig. 9). Zero the dial indicator. Position a large screwdriver between the camshaft gear and the block. Pull the camshaft forward and release it. Compare the dial indicator reading with the specifications listed at the end of the applicable engine section.

If end play is excessive, check the spacer for correct installation prior to removal. If the spacer is correctly installed, replace the thrust plate.

Remove the dial indicator and bracketry.

Timing Chain Deflection

1. Rotate the crankshaft counterclockwise (as viewed from the front) to take up the slack on the LH side of the chain.
2. Establish a reference point on the block and measure from this point to the chain (Fig. 10).
3. Rotate the crankshaft in the opposite direction to take up the slack on the RH side of the chain. Force the LH side of the chain out with the fingers and measure the distance between the reference point and the chain. Timing chain deflection is the difference between the two measurements.

   If the deflection exceeds specifications listed in the applicable engine Section, replace the timing chain and sprockets.

Timing Gear Backlash

Install Dial Indicator D78P-4201-G or equivalent, and Dial Indicator Bracketry D78P-4201-F or equivalent, on the cylinder block (Fig. 11). Check the backlash between the camshaft gear and the crankshaft gear with a dial indicator at six equally spaced teeth. Hold the gear firmly against the block while making the check. Refer to specifications in the applicable engine Section for backlash wear limits.

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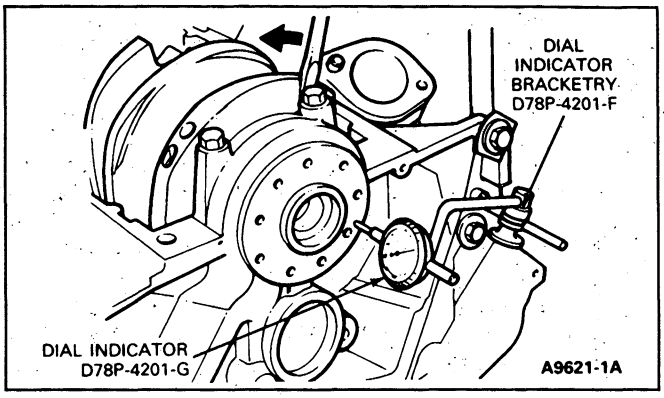


FIG. 12 Checking Crankshaft End Play

Crankshaft End Play

1. Force the crankshaft toward the rear of the engine.
2. Install Dial Indicator D78P-4201-G or equivalent, and Dial Indicator Bracketry D78P-4201-F or equivalent, so that the contact point rests against the crankshaft flange, and the indicator axis is parallel to the crankshaft axis (Fig. 12).
3. Zero the dial indicator. Push the crankshaft forward and note the reading on the dial.
4. If the end play exceeds the wear limit listed in the applicable engine section, replace the thrust bearing. If the end play is less than the minimum limit, inspect the thrust bearing faces for scratches, burrs, nicks, or dirt. If the thrust faces are not damaged or dirty, they probably were not aligned properly. Lubricate and install the new thrust bearing and align the faces following Main Bearing Replacement procedure in the applicable engine Section. Check the crankshaft end play.

Flywheel Clutch Face Runout—Manual-Shift Transmission

Remove the spark plugs.

Install Dial Indicator D78P-4201-G or equivalent, and Dial Indicator Bracketry D78P-4201-F or equivalent, so that the indicator point bears against the flywheel face (Fig. 13). Turn the flywheel, making sure that it remains fully forward or rearward so that crankshaft end play will not be indicated as flywheel runout.

If the flywheel clutch face runout exceeds specifications listed in the applicable engine Section, remove the flywheel and check for burrs between the flywheel and the face of the crankshaft mounting flange. If no burrs exist, check the runout of the crankshaft mounting flange. Replace the flywheel or machine the crankshaft-flywheel mounting face if the mounting face flange runout is excessive. If the ring gear runout exceeds specifications listed in the applicable engine Section, check installation of the gear to the flywheel flange. If it is not properly seated, install it to the flywheel. If it is properly seated and runout is excessive, replace it. Refer to Ring Gear Replacement for the proper procedure.

Install the spark plugs.

Flywheel Runout—Automatic Transmission

Remove the spark plugs.

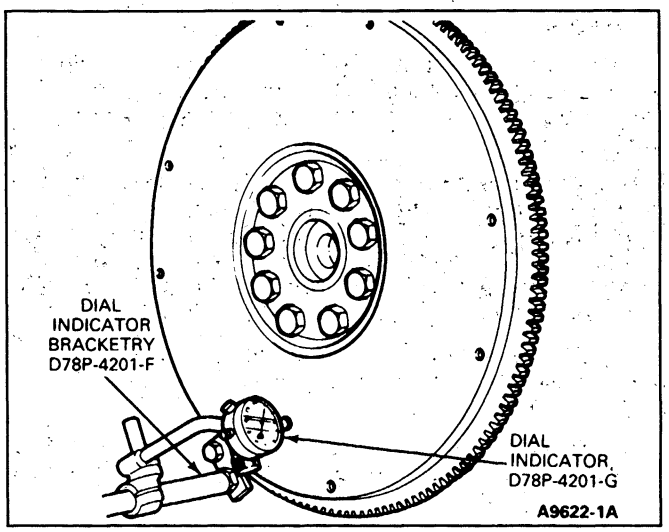


FIG. 13 Checking Flywheel Face Runout—Manual Transmission

Install a dial indicator so that the indicator point rests on the face of the ring gear adjacent to the gear teeth.

Push the flywheel and crankshaft forward or backward as far as possible to prevent crankshaft end play from being indicated as flywheel runout.

Set the indicator dial on the zero mark. Turn the flywheel one complete revolution while observing the total indicator reading (TIR). If the TIR exceeds specifications, the flywheel and ring gear assembly must be replaced.

Install the spark plugs.

EGR Valve

CAUTION: Do not strike or pry on the valve diaphragm housing or supports, as this may damage the valve operating mechanism and/or change the valve calibration. Refer to the Engine/ Emissions Diagnosis* manual.

Core Plugs

Removal and Installation

To remove a large core plug, drill a 12.70mm (1/2-inch) hole in the center of the plug. Remove plug using an Impact Slide Hammer T59L-100-B, T50T-100-A or equivalent, or pry it out with a large drift punch. On a small core plug, drill a 6.35mm (1/4-inch) hole in the center of the plug and pry it out with a small pin punch. Clean and inspect the plug bore.

Prior to installing a core plug, the plug bore should be inspected for any damage that would interfere with the proper sealing of the plug. If the bore is damaged it will be necessary to true the surface by boring for the next specified oversize plug.

Oversize (OS) plugs are identified by the OS stamped in the flat located on the cup side of the plug.

Coat the plug and/or bore lightly with an oil-resistant (oil galley) sealer. Use Perfect Seal Sealing Compound B5A-19554-A or equivalent sealer. Install core plug following the applicable procedure for cup type or expansion type.

*Can be purchased as a separate item.

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Cup-Type

Cup-type core plugs (Fig. 14) are installed with the flanged edge outward. The maximum diameter or sealing edge of this plug is located at the outer edge of the flange.

CAUTION: It is imperative to push or drive the plug into the machined bore using a properly designed tool. Under no circumstances is the plug to be driven into the bore using a tool that contacts the flange. This method will damage the sealing edge and will result in leakage and/or plug blowout.

The flanged (trailing) edge must be below the chamfered edge of the bore to effectively seal the plugged bore.

If the core plug replacing tool has a depth seating surface, do not seat the tool against a non-machined (casting) surface.

Expansion-Type

Install expansion-type core plugs (Fig. 14) with the flanged edge inward. The maximum diameter of this plug is located at the base of the flange with the flange flaring inward.

CAUTION: It is imperative to push or drive the plug into the machined bore using a properly designed tool. Under no circumstances is the plug to be installed using a tool that contacts the crowned portion of the plug. This method will expand the plug prior to installation and may damage the plug and/or plug bore.

When installed, the trailing (maximum) diameter must be below the chamfered edge of the bore to effectively seal the plugged bore.

If the core plug replacing tool has a depth seating surface, do not seat the tool against a non-machined (casting) surface.

Crankshaft Rear Oil Seal—One-Piece

The one-piece crankshaft rear oil seal is used on the 4.9L, 5.0L, 5.8L engines.

If crankshaft rear oil seal replacement is the only operation being performed, it can be done in the vehicle as detailed in the following procedure. **If the oil seal is being replaced in conjunction with a rear main bearing replacement, the engine must be removed from the vehicle and installed on a work stand.**

Removal

1. Remove the starter.
2. Remove the transmission from the vehicle, following the procedures in Group 16 (Manual Transmission) or Group 17 (Automatic Transmission) in the Body/Chassis/Electrical Manual.
3. On a manual-shift transmission, remove the pressure plate and cover assembly and the clutch disc following the procedure in Section 16-02, Clutch.
4. Remove the flywheel attaching bolts and remove the flywheel and engine rear cover plate.

   Using a sharp awl, punch one hole into the seal metal surface between the lip and block. Screw in the threaded end of Jet Plug Puller T77L-9533-B or equivalent. Use the plug puller to remove the seal. Use caution to avoid scratching or damaging the oil seal surface.
5. Clean the oil seal recess in the cylinder block and main bearing cap.

Installation

1. Clean, inspect, and polish the rear oil seal rubbing surface on the crankshaft as outlined.

   Coat a new oil seal and the crankshaft with a light film of engine oil.

CAUTION: DO NOT apply grease on seal for lubrication.

   Start the seal into the recess with the seal lip facing forward and install it with the Rear Oil Seal Replacer T65P-6701-A or equivalent, as shown in Fig. 15. Keep the tool straight with the centerline of the crankshaft and install the seal until the tool contacts the cylinder block surface. **Remove the tool and inspect the seal to ensure it was not damaged during installation.**
2. Install the engine rear cover plate. Position the flywheel on the crankshaft flange. Coat the threads of the flywheel attaching bolts with Pipe Sealant with TEFLON® D8AZ-19554-A or equivalent, and

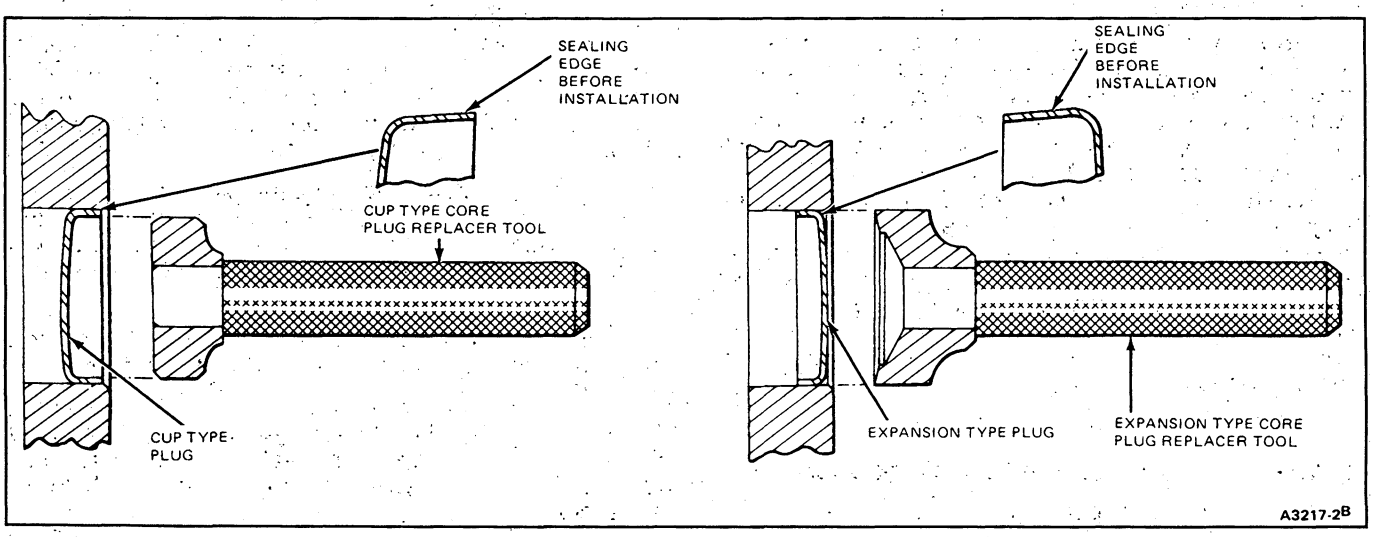


FIG. 14 Typical Core Plugs and Installation Tools

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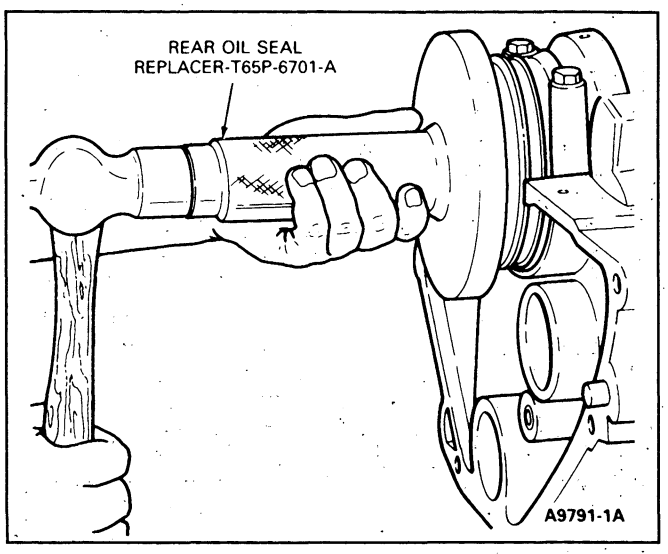


FIG. 15 Installing One-Piece Crankshaft Rear Oil Seal

install the bolts. Tighten the bolts in sequence across from each other to 102-115 N·m (75-85 ft-lb).

3. On a manual-shift transmission, install the clutch disc and the pressure plate assembly following the procedure in Section 16-02, Clutch.
4. Install the transmission following the procedure in Group 16 (Manual Transmission) or Group 17 (Automatic Transmission). **Do not adjust the transmission linkage.**

Crankshaft Rear Oil Seal

7.5L Engine

A split lip-type crankshaft rear oil seal is provided for servicing these engines. Refer to Section 21-24 7.5L (460CID) V-8 Engines, for additional sealing instructions and torque specifications.

Removal

1. Remove the oil pan and the oil pump, if required.
2. Loosen all the main bearing cap bolts, lowering the crankshaft slightly. Do not exceed 0.7938mm (1/32 inch).
3. Remove the rear main bearing cap, and remove the oil seal from the bearing cap and cylinder block. On the block half of the seal use a seal removal tool, or install a small metal screw in one end of the seal, and pull on the screw to remove the seal. **Exercise caution to prevent scratching or damaging the crankshaft seal surfaces.**

Installation

1. Carefully clean the seal groove in the cap and block with a brush and solvent such as lacquer thinner or Ford Extra Strength Spot and Stain Remover B7A-19521-AA or equivalent. Also, clean the area where sealer is later to be applied (Fig. 16). Dry the area thoroughly so that no solvent touches the seal.
2. Dip the split lip-type seal halves in clean engine oil.
3. Carefully install the upper seal (cylinder block) into its groove with undercut side of seal toward the FRONT of the engine (Fig. 17), by rotating it on the seal journal of the crankshaft until approximately 9.525mm (3/8 inch) protrudes below the parting surface.

Ensure no rubber has been shaved from the outside diameter of the seal by the bottom edge of the groove. Do not allow oil to get on the sealer area (Fig. 16).

4. Tighten the remaining bearing cap bolts to specifications.
5. Install the lower seal in the rear main bearing cap with undercut side of seal toward the FRONT of the engine (Fig. 17). Allow the seal to protrude approximately 9.525mm (3/8 inch) above the parting surface to mate with the upper seal when the cap is installed.
6. Apply an even 1.588mm (1/16 inch) bead of RTV Silicone Rubber Sealer D6AZ-19562-BA or equivalent to the areas shown in Fig. 16, following the procedure given in the illustration.

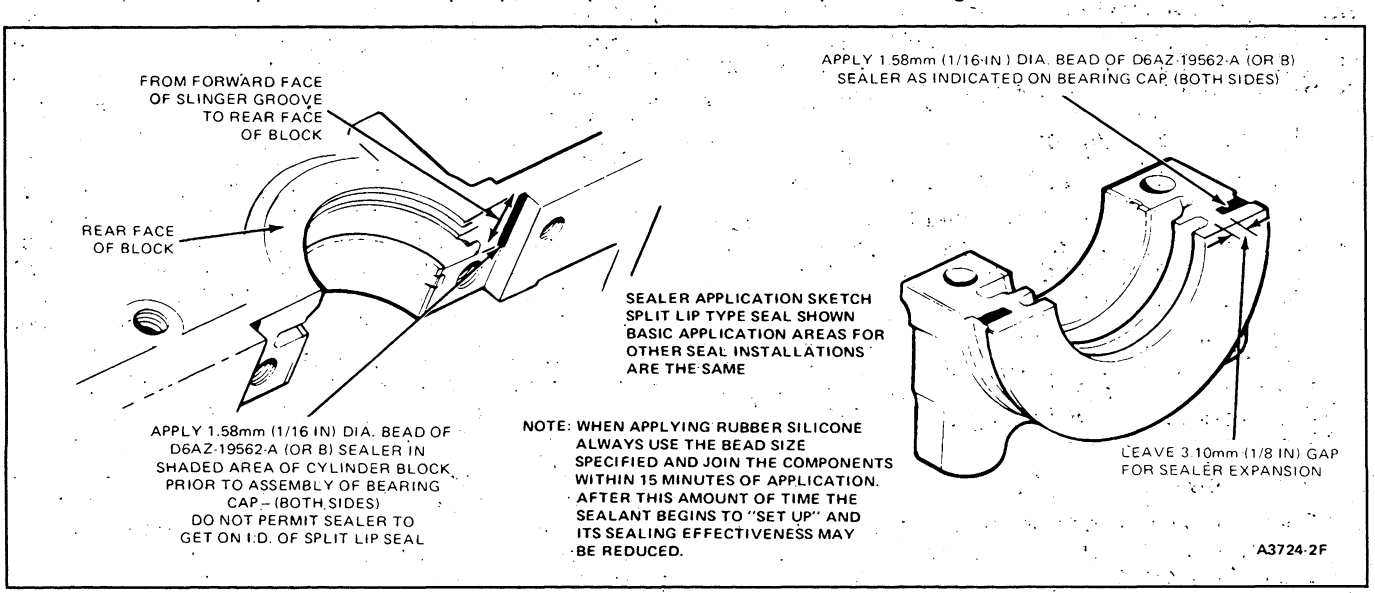


FIG. 16 Applying RTV Sealer to Main Bearing Cap and Block

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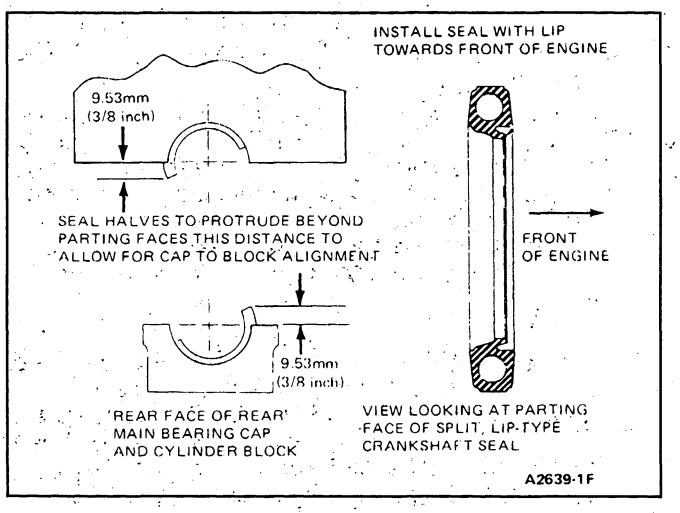


FIG. 17 Installing Crankshaft Rear Oil Seal

NOTE: when applying rubber silicone always use the bead size specified and join the components within 15 minutes of application. After this amount of time the sealant begins to "set-up" and its sealing effectiveness may be reduced.

Install the rear main bearing cap. Tighten the bolts to specifications listed in the specific engine Section.

7. Install the oil pump and oil pan. Fill the crankcase with the proper amount and type of oil.
8. Operate the engine and check for oil leaks.

Flywheel Ring Gear—Manual-Shift Transmission

Removal

To replace a damaged or worn ring gear, heat the ring gear with a blow torch on the engine side of the gear, and knock it off the flywheel. **Do not hit the flywheel when removing the ring gear.**

Installation

Heat the new ring gear evenly until the gear expands enough to slip onto the flywheel. Ensure the gear is seated properly against the shoulder. **Do not heat any portion of the gear to a temperature higher than 260°C (500°F). If this limit is exceeded, the hardness will be removed from the ring gear teeth.**

PCV Valve Replacement

1. Disconnect hose(s) and remove PCV valve.

   NOTE: If a high flow PCV valve is scheduled for installation, consult the Vehicle Emission Control Information Decal (VECI) for the correct high flow PCV valve part number.

   If replacement PCV valve requires a plastic fitting for additional vacuum lines, soak the new plastic fitting (furnished in PCV Valve Replacement Kit) in hot water prior to installing on new PCV valve. Proceed to Step 2.
2. Install new PCV valve and connect hose(s).
3. Check curb idle speed according to recommended procedures. Refer to the Engine/Emissions Diagnosis* manual, Section 4.

OVERHAUL

Interpretation of "Service Limit" Specifications

"Service Limit" specifications are intended for use as a guide only. Refer to them when overhauling or reconditioning an engine or engine component. "Service Limit" specifications assist decisions regarding component suitability for extended service (or replacement) while the engine is disassembled.

In the case of "Valve Stem-to-Valve Guide Clearance," the "Service Clearance" is intended as an aid in diagnosing engine noise only, and does not constitute a failure or indicate need for repair. However, when overhauling or reconditioning a cylinder head, the service clearance should be regarded as a practical working value, and used as a determinant for installing the next oversize valve to ensure extended service life.

Cylinder Head

Replace the head if it is cracked. **Do not plane or grind more than 0.254mm (0.010 inch) from the cylinder head gasket original surface.** Remove all burrs or scratches with Oil Stone D81L-6002-A.

Reaming Valve Guides

If it becomes necessary to ream a valve guide (Fig. 18) to install a valve with an oversize stem, use Valve Guide Reamer Kit T60K-6085-B, T56T-6085-A or equivalent containing the following reamer and pilot combinations: a 0.015-inch OS reamer with a 0.003-inch OS pilot, and a 0.030-inch reamer with a 0.015-inch OS pilot.

When replacing a standard size valve with an oversize valve always use the reamer in sequence (smallest oversize first, then next smallest, etc.) so as not to overload the reamers. **Always reface the valve seat after the valve guide has been reamed, and use a suitable scraper to break the sharp corner (ID) at the top of the valve guide.**

Refacing Valve Seats

Refacing of the valve seat should be closely coordinated with the refacing of the valve face so that the finished seat and valve face will be concentric and maintain the specified interference fit. This is important so that the valve and seat will have a compression-tight fit. Ensure the refacer grinding wheels are properly dressed.

Grind the valve seats of all engines to a true 45-degree angle (Fig. 21). Remove only enough stock to clean up pits and grooves or to correct the valve seat runout. After the seat has been refaced, use a seat width scale or a machinist scale to measure the seat width (Fig. 20). Narrow the seat, if necessary to bring it within specifications. Refer to applicable engine section.

If the valve seat width exceeds the maximum limit, remove enough stock from the top edge and/or bottom edge of the seat to reduce the width to specifications. Refer to applicable engine section.

On the valve seats of all engines, use a 60-degree angle grinding wheel to remove stock from the bottom of the seats (raise the seats). Use a 30-degree angle wheel to remove stock from the top of the seats (lower the seats) (Fig. 19).

*Can be purchased as a separate item.

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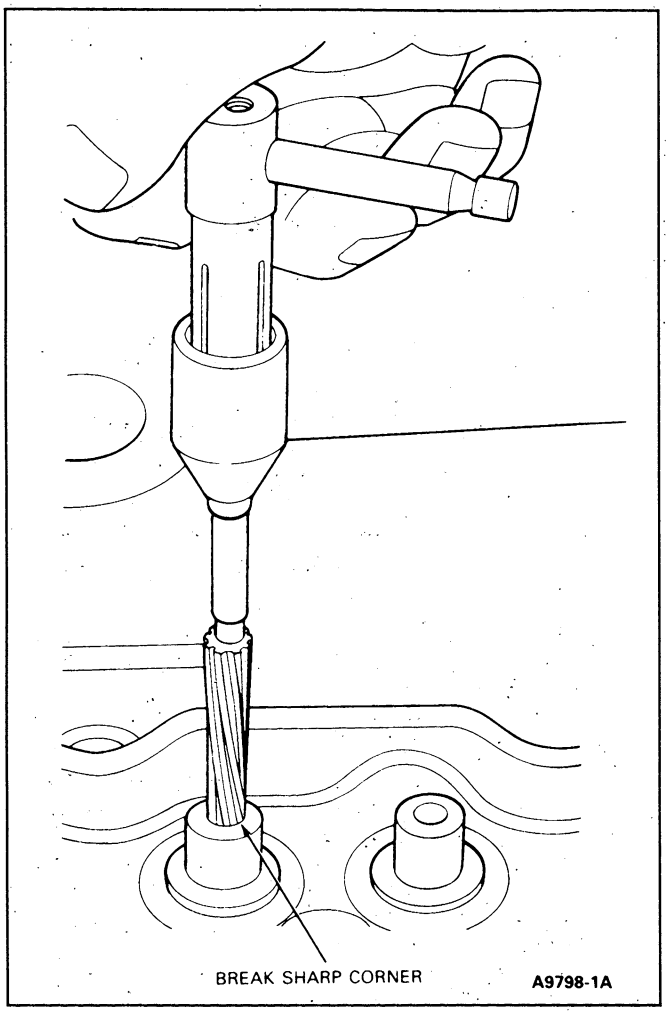


FIG. 18 Reaming Valve Guides

The finished valve seat should contact the approximate center of the valve face. It is good practice to determine where the valve seat contacts the face. To do this, coat the seat with Prussian blue and set the valve in place. Rotate the valve with light pressure. If the blue is transferred to the center of the valve face, the contact is satisfactory. If the blue is transferred to the top edge of the valve face, lower the valve seat. If the blue is transferred to the bottom edge of the valve face, raise the valve seat.

Valves

Minor pits, grooves, etc., may be removed. Discard valves that are severely damaged, if face runout cannot be corrected by refinishing, or if stem clearance exceeds specifications. Refer to applicable engine section.

Discard any worn or damaged valve train parts.

Refacing Valves

The valve refacing operation should be closely coordinated with the valve seat refacing operations so that the finished angles of the valve face and of the valve seat will be within specification and provide a compression-tight fit. Ensure the refacer grinding wheels are properly-dressed.

If the valve face runout is excessive and/or pitted and grooved, reface the valves to a true 44-degree angle. Remove only enough stock to correct the runout or to

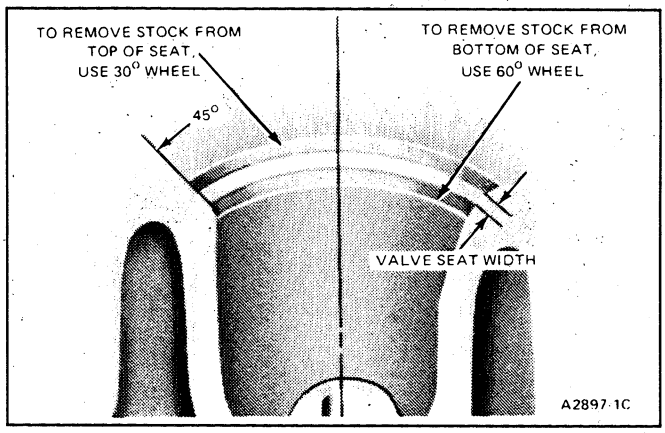


FIG. 19 Refacing Valve Seat

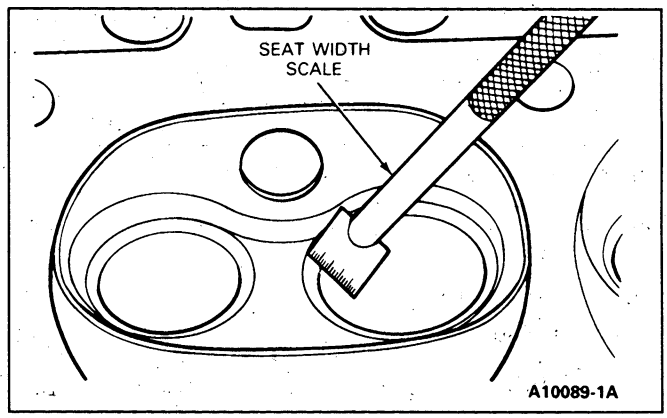


FIG. 20 Checking Valve Seat Width

clean up the pits and grooves. If the edge of the valve head is less than 0.794mm (1/32-inch) thick after grinding (Fig. 21), replace the valve, as the valve will run too hot in the engine. **The interference fit of the valve and seat should not be lapped out.**

Remove all grooves or score marks from the end of the valve stem, and chamfer it as necessary. **Do not remove more than 0.254mm (0.010 inch) from the end of the valve stem.**

If the valve and/or valve seat has been refaced, it will be necessary to check the clearance between the rocker arm pad and the valve stem tip with the valve train assembly installed in the engine.

Select Fitting Valves

If the valve stem-to-valve guide clearance exceeds the service limit, ream the valve guide for the next oversize valve stem. Valves with oversize stem diameters of 0.003, 0.015, and 0.030 inch are available for service. **Always reface the valve seat after the valve guide has been reamed. Refer to Reaming Valve Guides.**

Camshaft Repair

Remove light scuffs, scores or nicks from the camshaft machined surfaces with Oil Stone D81L-6002-A or equivalent.

Crankshaft

Dress minor scores with Oil Stone D81L-6002-A or equivalent. If the journals are severely marred or exceed

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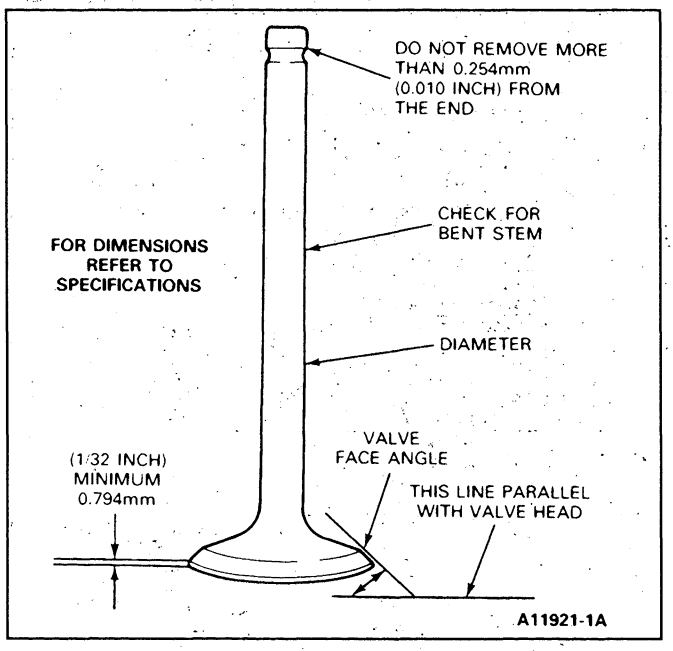


FIG. 21 Critical Valve Dimensions

the service limit, refinish them to size for the next undersize bearing.

Refinishing Journals

Refinish the journals to give the proper clearance with the next undersize bearing. If the journal will not clean up to fit maximum undersize bearing available, replace the crankshaft.

Always reproduce the original journal shoulder radius. Too small a radius will result in fatigue failure of the crankshaft. Too large a radius will result in bearing failure due to radius ride of the bearing.

After refinishing the journals, chamfer the oil holes; then polish the journal with a No. 320 grit polishing cloth and engine oil. Crocus cloth may also be used as a polishing agent.

Fitting Main or Connecting Rod Bearings with Plastigage

1. Clean crankshaft journals. Inspect journals and thrust faces (thrust bearing) for nicks, burrs or bearing pickup that would cause premature bearing wear. When replacing standard bearings with new bearings, fit the bearing to minimum specified clearance. If the desired clearance cannot be obtained with a standard bearing, try one half of a 0.001 or 0.002 inch undersize in combination with a standard bearing to obtain the proper clearance.
2. If fitting a main bearing, position a jack under counterweight adjoining bearing which is being checked. **Do not place jack under front post of crankshaft.** Support crankshaft with jack so its weight will not compress Plastigage and provide an erroneous reading.
3. Place a piece of Plastigage D81L-6002-B or equivalent on bearing surface across full width of bearing cap and about 6.35mm (1/4 inch) off center (Fig. 22).
4. Install cap and tighten bolts to specifications. Refer to applicable engine section. Do not turn crankshaft while Plastigage is in place.

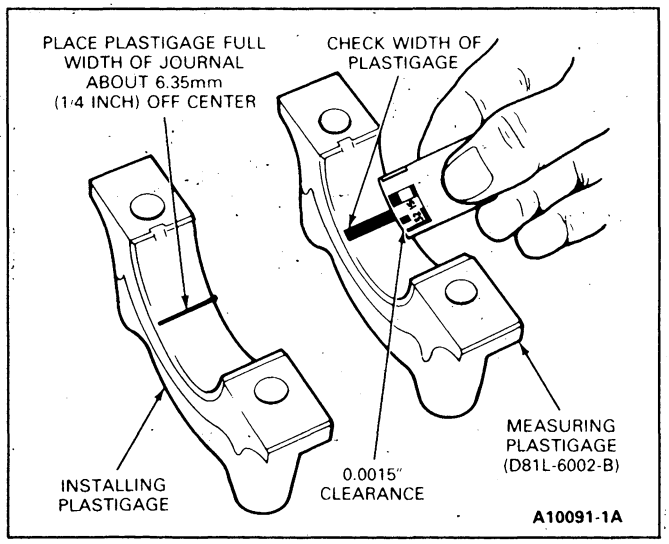


FIG. 22 Installing and Measuring Plastigage—Engine Installed

5. Remove cap. Using Plastigage scale, check width of Plastigage at widest point to get minimum clearance. Check at narrowest point to get maximum clearance. Difference between readings is taper of journal.
6. If clearance exceeds specified limits, try a 0.001 or 0.002 inch undersize bearing in combination with the standard bearing. Bearing clearance must be within specified limits. If 0.002 inch undersize main bearings are used on more than one journal, be sure they are all installed in cylinder block side of bearing. If standard and 0.002 inch undersize bearing does not bring clearance within desired limits, refinish crankshaft journal, then install undersize bearings.
7. After bearing has been fitted, apply light coat of engine oil to journal and bearings. Install bearing cap and cap bolts. Tighten cap bolts to specifications. Refer to specific engine Section.
8. Repeat procedures for remaining bearings requiring replacement.

Pistons, Pins and Rings

Fitting Pistons

For specifications refer to applicable engine section.

Pistons are available in standard size or oversize for service. Refer to the Ford Parts Master Catalog for available oversize pistons.

The standard size pistons are color coded red, blue, or yellow or have 0.003 OS stamped on the dome. Refer to Specifications for standard size piston dimensions.

NOTE: Cylinder bore must be clean and dry, and engine block must remain at room temperature for eight hours before taking cylinder measurements.

Measure the cylinder bore using Cylinder Bore Micrometer D84P-6011-B or equivalent. Refer to Fig. 23.

Each cylinder must be checked for out-of-round conditions prior to fitting the piston. (Out-of-round is the difference between the two bore measurements of each cylinder—taken parallel and perpendicular to the centerline of the crankshaft.) Refer to Fig. 24.

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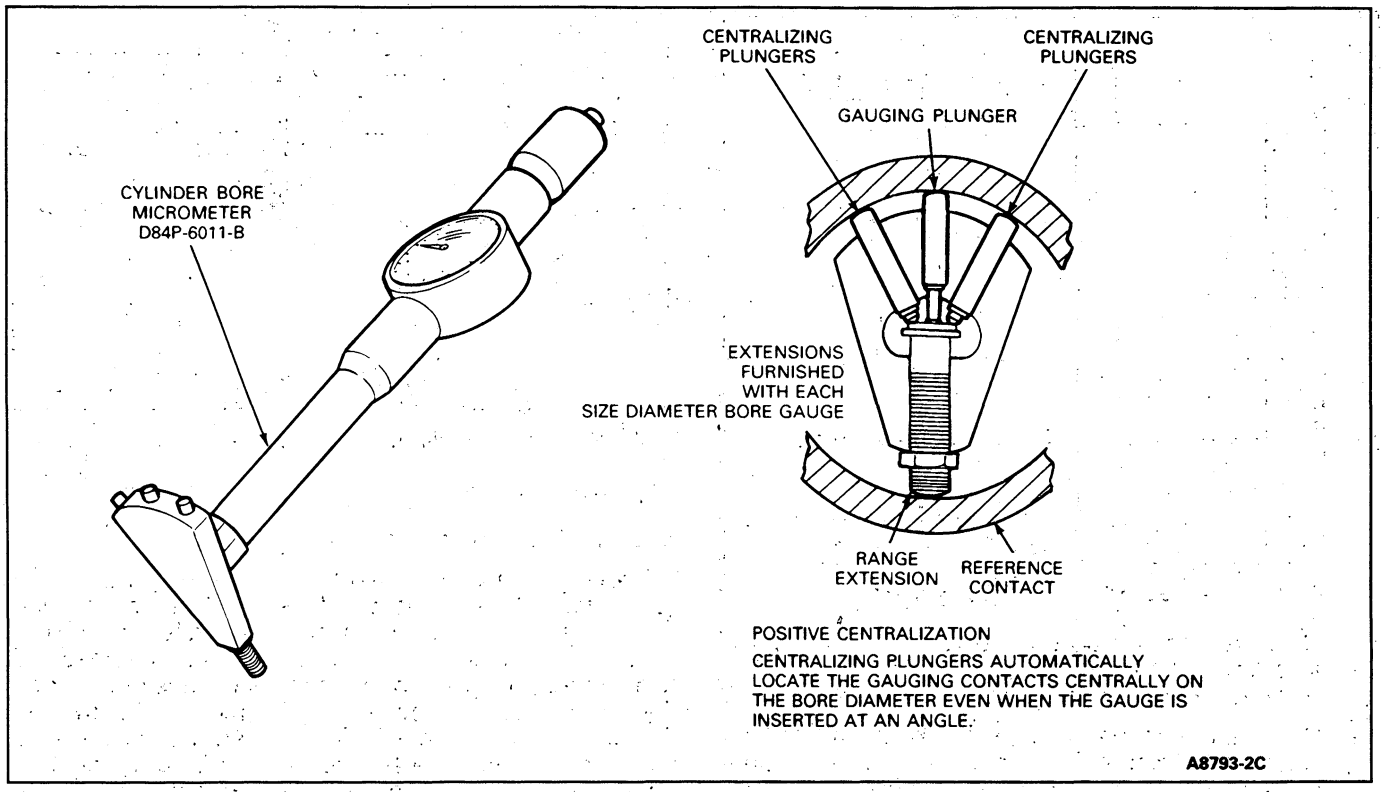


FIG. 23 Cylinder Bore Micrometer

These measurements must be performed at the top, middle, and bottom of the ring travel area of the cylinder bore. Refer to Fig. 25.

Each cylinder bore must be checked for excessive taper before fitting the piston. (Taper is defined as the difference between two bore diameters measured at the top and bottom of the cylinder bore ring travel area.) Both measurements must be made perpendicular to the crankshaft centerline.

Refer to the General Specifications, Cylinder Block section of the applicable engine Section Cylinder Block Section of the applicable Powertrain Shop Manual. This listing includes maximum allowable service limits (differences in the two measurements) for out-of-round cylinder bore. This listing also provides maximum allowable service limits for excessive cylinder bore taper. If beyond allowable service limits for taper and/or out-of-round dimensions, the cylinder must be rebored and/or honed to comply with piston clearance and fit requirements.

If the cylinder bore is within the acceptable limits for out-of-round and taper, the proper piston can be selected. The proper service piston is determined by measuring perpendicular to the crankshaft centerline at the middle of the ring travel area. Refer to Fig. 22. Repeat the measurement three times and divide the sum of the three diameters by three to determine the average dimension.

Average Dimension = Dimension No. 1+Dimension No. 2+Dimension No. 3÷3.

Measure the piston diameter to ensure that the specified clearance is obtained. It may be necessary to periodically use another piston (within the same grade size) that is either slightly larger, or smaller to achieve the specified clearance.

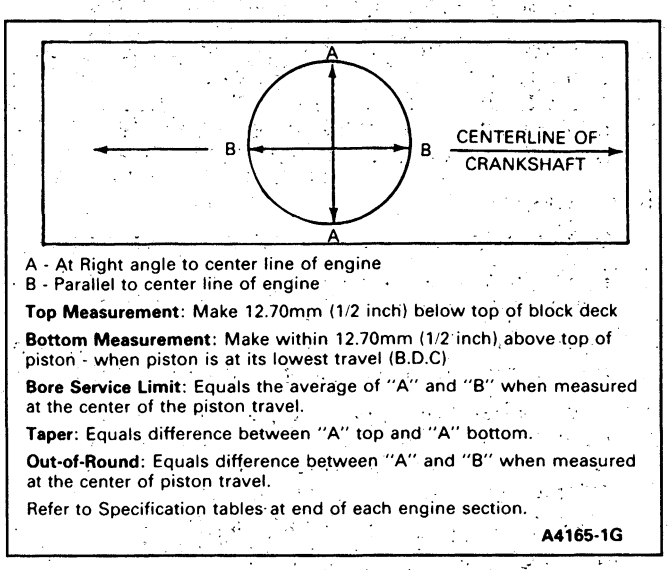


FIG. 24 Cylinder Bore Measurement

If none can be fitted, refinish the cylinder to provide the proper clearance for the piston.

When a piston has been fitted, mark it for assembly in the cylinder to which it was fitted.

If the taper, out-of-round and piston-to-cylinder bore clearance conditions are within specified limits, new piston rings will give satisfactory service. **If new rings are to be installed in a used cylinder that has not been refinished, remove the cylinder wall glaze. Refer to Cylinder Block, Refinishing Cylinder Walls. Always clean the cylinder bore thoroughly with soap and water.**

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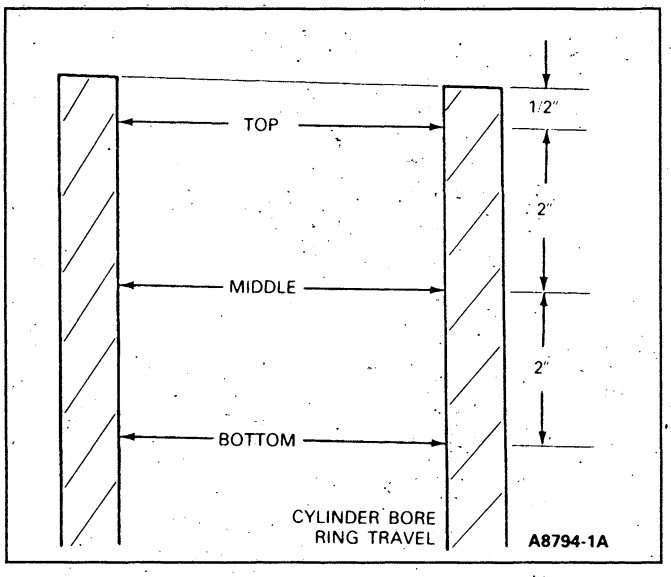


FIG. 25 Cylinder Bore Travel Measurement

1. Calculate the size piston to be used by performing a cylinder bore check. Follow the procedures outlined under Cleaning and Inspection.
2. Select the proper size piston to provide the desired clearance. Refer to Specifications in the applicable engine section. Measure the piston diameter in line with the centerline of the piston pin and at 90 degrees to the piston pin axis.
3. Ensure the piston and cylinder block are at room temperature (21.1°C or 70°F). After any refinishing and washing operation allow the cylinder bore to cool. Ensure the piston and bore are clean and dry before the piston fit is checked.

Fitting Rings

1. Select the proper ring set for the cylinder bore size.
2. Position the ring in the cylinder bore in which it is going to be used.
3. Push the ring down into the bore area where normal ring wear is not encountered.
4. Use the head of a piston to position the ring in the bore so that the ring is square with the cylinder wall. Use caution to avoid damage to the ring or cylinder bore.
5. Measure the gap between the ends of the ring with a feeler gauge (Fig. 26). Ring gap in a worn cylinder is normally greater than specification. If the ring gap is greater than the specified limits, try another ring set listed in the applicable engine section.
6. Check compression ring side clearance with a feeler gauge inserted between the ring and its lower land according to specification in the applicable engine section (Fig. 27). The gauge should slide freely around the entire ring circumference without binding. Any wear that occurs will form a step at the inner portion of the lower land. If the lower lands have high steps, the piston must be replaced.

Fitting Piston Pins

Install the piston pin following the procedure under Piston Assembly in the applicable engine section.

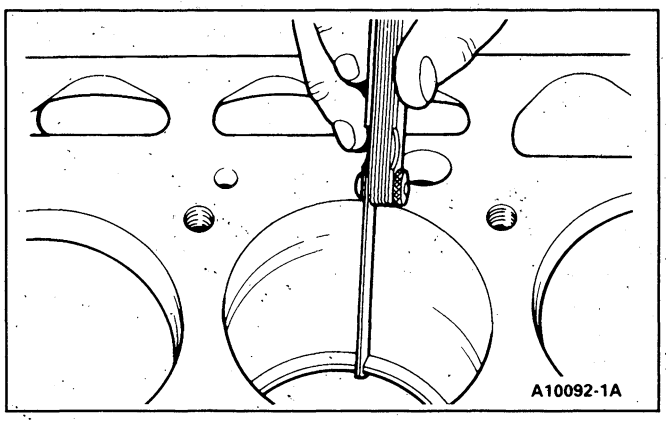


FIG. 26 Checking Piston Ring Gap

Cylinder Block

Refinishing Cylinder Walls

Honing is recommended for refinishing cylinder walls only when there is no visible sign of cross hatching (hone pattern) remaining, when the walls have minor scuffs or scratches, or for fitting pistons to the specified clearance. The grade of hone to be used is determined by the amount of metal to be removed. Follow the instructions of the hone manufacturer. If coarse stones are used to start the honing operation, leave enough material so that all hone marks can be removed with the finishing hone which is used to obtain the proper piston clearance. Thoroughly clean the cylinder bore walls with detergent and water solution after honing.

Cylinder walls that are severely marred and/or worn beyond the specified limits should be refinished. **Before any cylinder is refinished, all main bearing caps must be in place and tightened to specification, so that the crankshaft bearing bores will not become distorted from the refinishing operation. Refer to the specific engine Section.**

Refinish only the cylinder or cylinders that require it. All pistons are the same weight, both standard and oversize; therefore, various sizes of pistons can be used without upsetting engine balance.

Refinish the cylinder with the most wear first to determine the maximum oversize. If the cylinder will not clean up when refinished for the maximum oversize piston recommended, replace the block.

Refinish the cylinder to within approximately 0.04mm (0.0015 inch) of the required oversized diameter. This will allow enough stock for the final step of honing so that the correct surface finish and pattern are obtained.

For the proper use of the refinishing equipment, follow the instructions of the manufacturer. Only experienced technicians should be allowed to perform this work.

Use a motor-driven, spring pressure-type hone at a speed of 300-500 rpm. Hones of grit sizes 180-220 will normally provide the desired bore surface finish. When honing the cylinder bores, use a lubricant mixture of equal parts of kerosene and SAE No. 20 Motor Oil. Operate the hone in such a way as to produce a cross-hatch finish on the cylinder bore. The cross-hatch pattern should be at an angle of approximately 30 degrees to the cylinder bore.

After the final operation in either of the two refinishing methods described, and prior to checking the piston fit,

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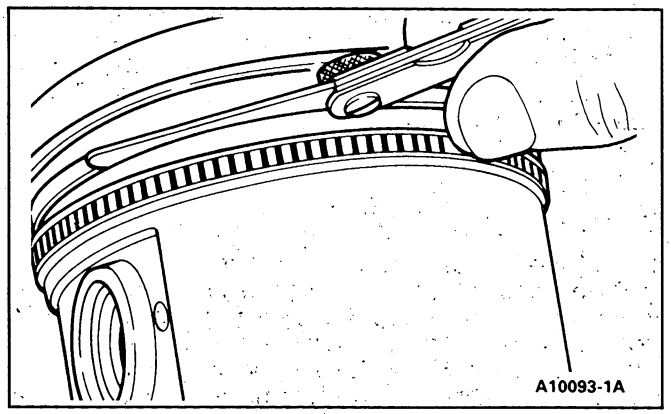


FIG. 27 Checking Piston Ring Side Clearance

thoroughly clean the cylinder walls with detergent and water solution, dry thoroughly and oil the cylinder walls. Mark the pistons to correspond to the cylinders in which they are to be installed. When all necessary cylinder refinishing has been completed and all pistons are fitted, thoroughly clean the entire block and oil the cylinder walls.

Repairing Engine Castings With Sand Holes or Porosity

Porosity or sand hole(s) causing oil seepage or leakage can occur with modern casting processes. A complete inspection of the engine should be made. If the leak is attributed to the porous condition of the cylinder block or sand hole(s), repairs can be made with Metallic Plastic (Epoxy Resin) C6AZ-19554-A or an equivalent metallic plastic. **Do not repair cracks with this material. Repairs with this metallic plastic (Epoxy Resin) must be confined to those cast iron engine component surfaces (Fig. 28) where the inner wall surface is not exposed to engine coolant pressure or oil pressure.** For example:

a. Cylinder block surfaces extending along the length of the block, upward from the oil pan rail to the cylinder water jacket but not including machined areas.

b. Lower rear face of the cylinder block.

c. Intake manifold casting. Repairs are not recommended to the intake manifold exhaust crossover section since temperature can exceed the recommended temperature limit of metallic plastic (260°C or 500°F).

d. Cylinder front cover on engines using cast iron material.

e. Cylinder head, along the rocker arm cover gasket surface.

The following procedures should be used to repair porous areas or sand holes in cast iron:

1. Clean the surface to be repaired by grinding or rotary filing to a clean, bright metal surface. Chamfer or undercut the hole or porosity to a greater depth than the rest of the cleaned surface. Solid metal must surround the hole. Openings larger than 6.35mm (1/4 inch) should not be repaired using metallic plastic (Epoxy Resin). Openings in excess of 6.35mm (1/4 inch) can be drilled, tapped and plugged using common tools.

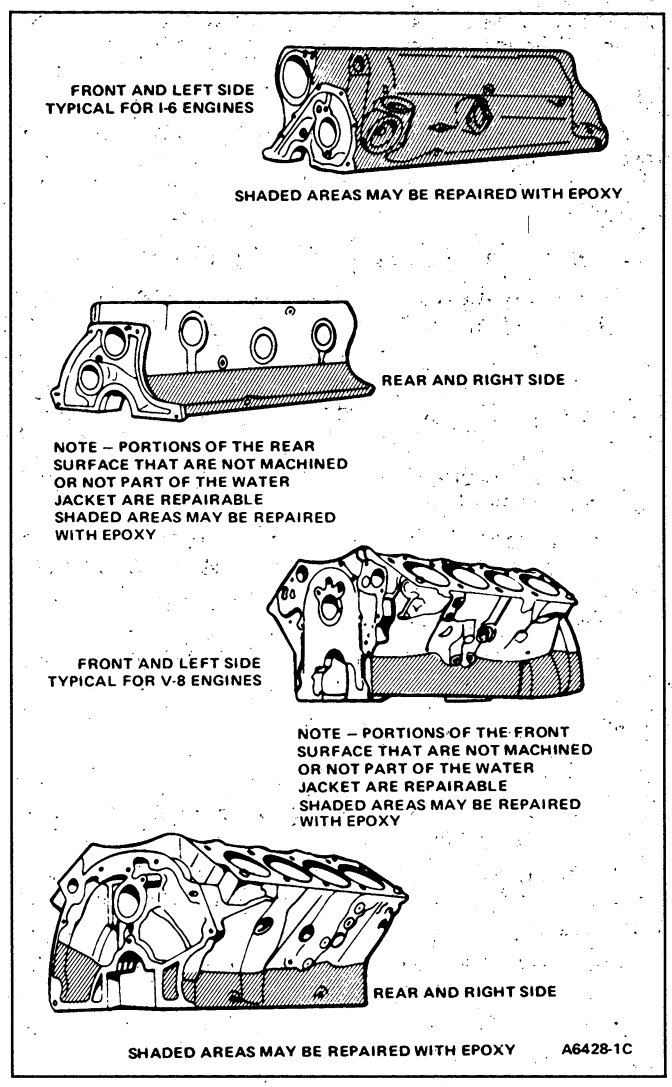


FIG. 28 Typical Cast Iron Cylinder Block Areas Repairable with Metallic Plastic (Indicated by Shaded Areas)

Clean the repair area thoroughly. Metallic plastic will not stick to a dirty or oily surface.

2. Mix the Epoxy Resin base and hardener as directed on the container. Stir thoroughly until uniform.

3. Apply the repair mixture with a suitable clean tool (putty knife, wood spoon, etc.), forcing the metallic plastic into the hole or porosity.

4. Allow the repair mixture to harden. This can be accomplished by two methods: heat cure with a 250-watt lamp placed 254mm (10 inches) from the repaired surface, as directed on the package label, or air dry for 10-12 hours at temperatures above 10°C (50°F).

5. Sand or grind the repaired area to blend with the general contour of the surrounding surface.

6. Paint the surface to match the rest of the block.

CLEANING AND INSPECTION

The cleaning and inspection procedures are for a complete engine overhaul; therefore, for partial engine

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overhaul or parts replacement, follow the appropriate cleaning or inspection procedure.

Crankcase Ventilation System

Refer to Section 10-02, Maintenance for the correct mileage interval for maintenance. Service the system following procedures in the Engine/Emissions Diagnosis* manual.

PCV System, Hoses and Tubes—Clean

1. Remove the PCV system components, filler cap, PCV valve, hoses, tubes, fittings, etc. from the engine.
2. Clean the rubber ventilation hose(s) by passing a suitable cleaning brush through each of them.
3. Thoroughly wash the rubber hoses in a low volatility petroleum base solvent and dry with compressed air.
4. Thoroughly wash the crankcase breather cap, if so equipped, in a low volatility petroleum base solvent and shake dry. Refer to Crankcase Breather Cap—Clean.
5. Thoroughly clean tubes, fittings and connections to ensure unobstructed flow of emission gases.

Valve Rocker Arm

Cleaning

Clean all the parts thoroughly. Ensure that all oil passages are open.

On spherical and cylindrical fulcrum seat rocker arms, ensure the oil passage in the push rod end of the rocker arm is open.

If necessary, remove the plugs from both ends of the rocker arm shaft to thoroughly clean the shaft passages.

Inspection

Inspect the pad at the valve end of the rocker arms for indications of scuffing or abnormal wear. If the pad is grooved, replace the rocker arm. **Do not attempt to true this surface by grinding.**

On spherical and cylindrical fulcrum seat rocker arms, check the fulcrum seat for excessive wear, cracks, nicks or burrs. Check rocker arm studs and nuts for stripped or broken threads, or looseness.

Valve Rocker Arm Covers

Check the gasket surfaces for damage caused by over-tightened bolts. Straighten the surface as required to restore original flatness.

NOTE: DO NOT attempt to service 7.5L aluminum rocker arm covers. Damaged covers should be replaced with service covers.

Push Rods

Cleaning

Clean all push rods in a suitable solvent. On push rods with an oil passage, blow out the passage with compressed air.

Inspection

Check the ends of the push rods for nicks, grooves, roughness or excessive wear.

The push rods can be visually checked for straightness while they are installed in the engine by rotating them with the valve closed. They also can be checked with a Dial Indicator with Bracketry TOOL-4201-C or equivalent (Fig. 29).

Cylinder Heads

Cleaning

With the valves installed to protect the valve seats, remove deposits from the combustion chambers and valve heads with a scraper and a wire brush. **Be careful not to damage the cylinder head gasket surface.** After the valves are removed, clean the valve guide bores with a valve guide cleaning tool. Use cleaning solvent to remove dirt, grease and other deposits. Clean all bolt holes. Ensure the oil transfer passage is clean (V-8 engines).

Remove all deposits from the valves with a fine wire brush or buffing wheel.

Inspection

Inspect the cylinder heads for cracks or excessively burned areas in the exhaust outlet ports.

Check the cylinder head for cracks. Inspect gasket surface for burrs and nicks. Replace the head if it is cracked. Service burrs and nicks as necessary.

On cylinder heads that incorporate valve seat inserts, check the inserts for excessive wear, cracks or looseness.

The following inspection procedures are for a cylinder head that is to be completely overhauled. For individual repair operations, use only the pertinent inspection procedure.

Cylinder Head Flatness

When a cylinder head is removed because of gasket leaks, check the flatness of the cylinder head gasket surface (Fig. 30), using Straight Edge D83L-4201-A for conformance to specifications according to applicable engine sections. If cylinder head gasket surface refinishing is necessary, do not plane or grind off more than 0.254mm (0.010 inch) from the original gasket surface.

Valve Seat Runout

Check the valve seat runout with an accurate Valve Seat Runout Gauge D81P-6002-E (Fig. 31) or equivalent. Follow the instructions of the gauge manufacturer. If the runout exceeds the service limit, reface the valve and valve seat.

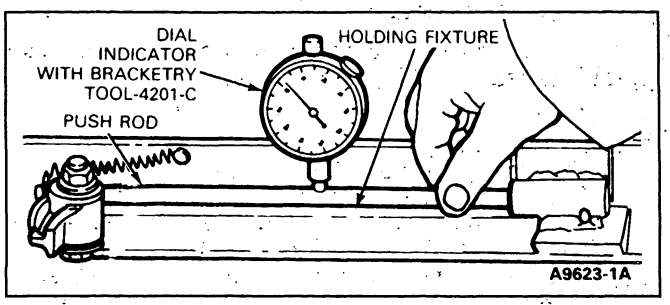


FIG. 29 Checking Push Rod Runout

*Can be purchased as a separate item.

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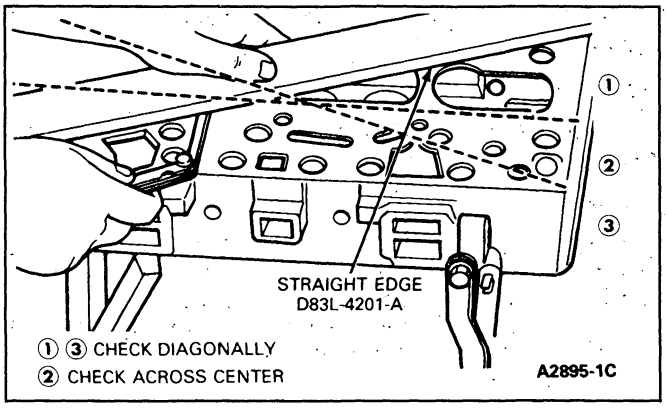


FIG. 30 Checking Cylinder Head Flatness—Typical

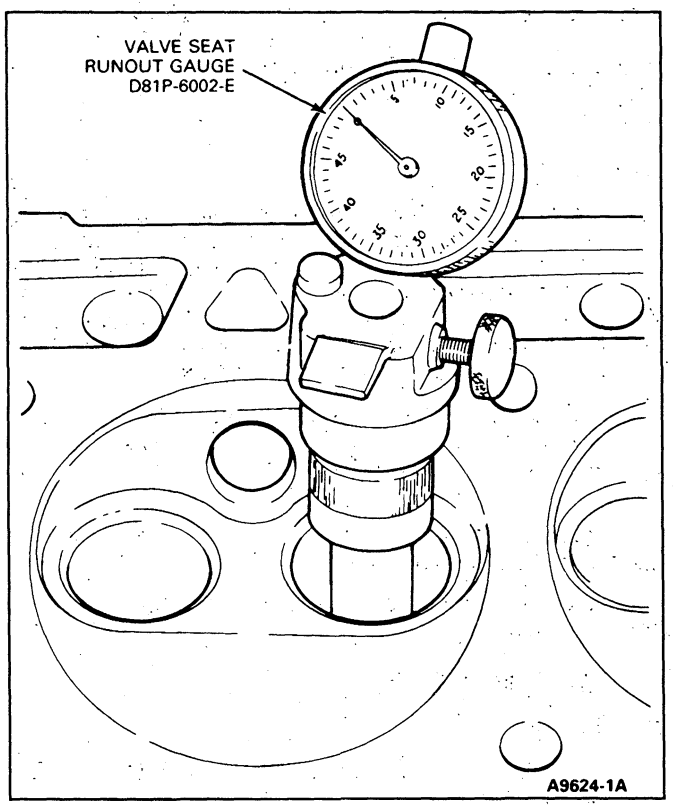


FIG. 31 Checking Valve Seat Runout

Valve Seat Width

Measure the valve seat width (Fig. 20). Reface the valve seat(s) if the width is not within specifications. Refer to applicable engine Section.

Valves

The critical inspection points and tolerances of the valve are illustrated in Fig. 27. Refer to specifications for service limits. Refer to applicable engine Section.

Inspect the valve face and the edge of the valve head for pits, grooves or scores. Inspect the stem for a bent condition and the end of the stem for grooves or scores. Check the valve head for signs of burning or erosion, warpage and cracking. Minor pits, grooves, etc., may be removed. Discard severely damaged valves.

Inspect the valve springs, valve spring retainers, locks and sleeves and discard any visually damaged parts.

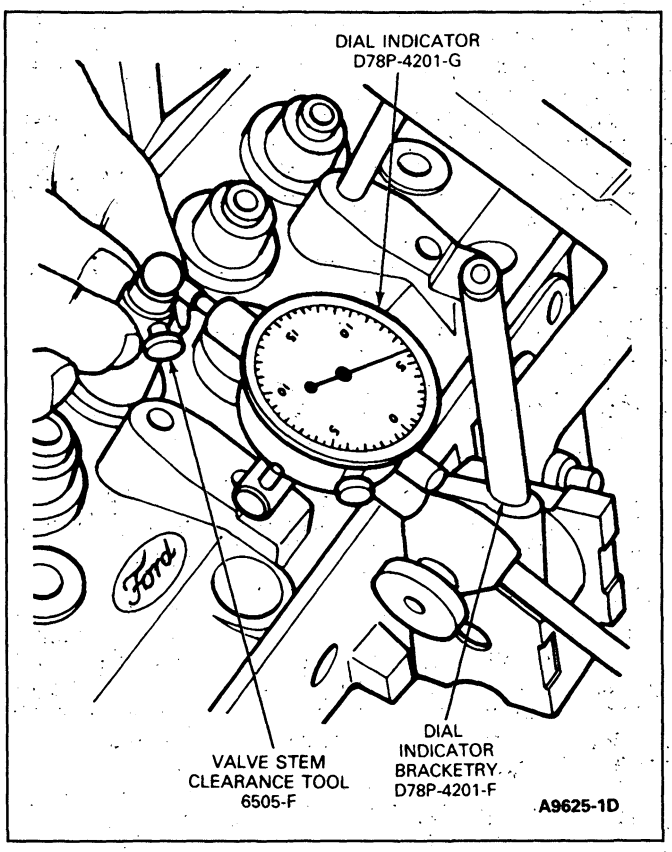


FIG. 32 Checking Valve Stem Clearance—Typical

Valve Face Runout

Check the valve face runout. It should not exceed the specified service limit. If the runout exceeds the service limit, the valve should be replaced or refaced as outlined under Refacing Valves.

Valve Stem Clearance

Check the valve stem-to-guide clearance. Check each valve in its respective valve guide with Valve Stem Clearance Tool TOOL-6505-E (11/32-inch valves) or the equivalent (Fig. 32). Use a flat end indicator point.

Install the tool on the valve stem until it is fully seated, and tighten the knurled set screw firmly. Permit the valve to drop away from its seat until the tool contacts the upper surface of the valve guide.

Position the dial indicator with its flat tip against the center portion of the tool's spherical section at approximately 90 degrees to the valve stem axis. Move the tool back and forth in line with the indicator stem. Take a reading on the dial indicator without removing the tool from the valve guide upper surface. Divide the reading by two, the division factor for the tool. If valve stem-to-valve guide clearance exceeds the wear limit, ream the valve guide for the next oversize valve stem as outlined under Valves.

Valve Spring Pressure

Check the valve spring for proper pressure (Fig. 33) at the specified spring lengths using Valve/Clutch Spring Tester TOOL-6513-DD or equivalent. Weak valve springs cause poor performance; therefore, if the pressure of any spring is lower than the service limit, replace the spring.

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Valve Spring Squareness

Check each spring for squareness using a steel square and a surface plate (Fig. 34). Stand the spring and square on end on the surface plate. Slide the spring up to the square. Rotate the spring slowly and observe the space between the top coil of the spring and square. If the spring is out of square more than 1.984mm (5/64 inch), replace it.

Follow the same procedure to check new valve springs before installation.

Ensure the proper spring (color coded) is installed.

Intake Manifold(s)

Cleaning

Remove all gasket material from the machined surfaces of the manifold(s). Clean the manifold(s) in a suitable solvent and dry it with compressed air.

Inspection

Inspect the manifold(s) for cracks, nicked gasket surfaces, or other damage that would make it unfit for further service. Replace all studs that are stripped or otherwise damaged. **Remove all filings and foreign matter that may have entered the manifold as a result of repairs.**

Exhaust Manifolds

Cleaning

Remove all gasket material from the manifold(s).

Inspection

Inspect the manifold(s) for cracks, damaged gasket surfaces, or other wear or damage that would make them unfit for further service. Inspect the cylinder head joining flanges of the exhaust manifold(s) for evidence of exhaust gas leaks.

Hydraulic Valve Tappets

The valve tappet assemblies should be kept in proper sequence so that they can be installed in their original position. Inspect and test each tappet separately to avoid mixing the internal parts. **If any part of the tappet assembly needs replacing, replace the entire assembly.**

Cleaning

Thoroughly clean all parts in clean solvent and wipe them with a clean, lint-free cloth.

Inspection

Inspect the parts and discard the entire tappet assembly if any part shows pitting, scoring, galling or evidence of non-rotation. Replace the entire assembly if the plunger is not free in the body. The plunger should drop to the bottom of the body by its own weight when assembled dry.

Assemble the tappet assembly and check for freeness of operation by pressing down on the push rod cup. The tappets can also be checked with a hydraulic tester to test the leak-down rate. Follow the instructions of the test unit manufacturer or the Hydraulic Valve Tappet procedure under Diagnosis and Testing in this Section.

Camshaft

Clean the camshaft in solvent and wipe it dry. Inspect the camshaft lobes for scoring and signs of abnormal wear. Lobe wear characteristics may result in pitting in the general area of the lobe toe. This pitting will not affect operation of the camshaft; therefore, the camshaft should not be replaced unless the camshaft lobe lift loss has exceeded specifications.

The lift of camshaft lobes can be checked with the camshaft installed in the engine or on centers. Refer to Camshaft Lobe Lift under Diagnosis and Testing in this Section.

Replace the camshaft if the distributor drive gear is broken or has chipped teeth.

Check the fuel pump eccentric, if so equipped, for excessive wear.

Timing Chain and Sprockets

Cleaning

Clean all parts in solvent and dry them with compressed air.

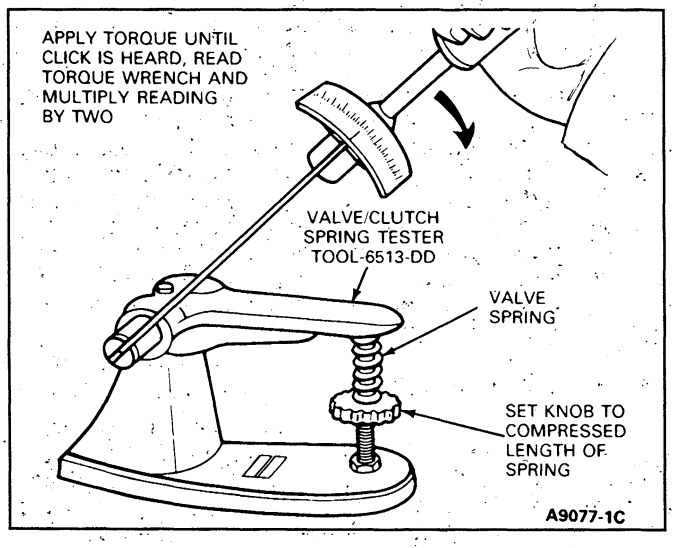


FIG. 33 Checking Valve Spring Pressure

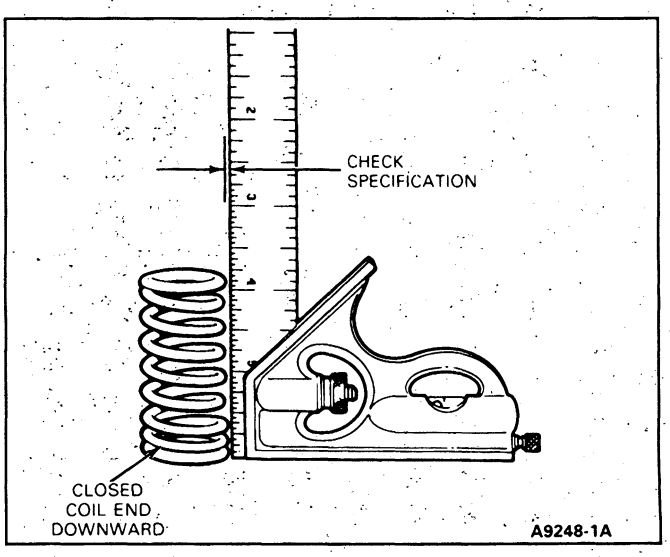


FIG. 34 Checking Valve Spring Squareness

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Lubricate the timing chain with engine oil before installing it on the engine.

Inspection

Inspect the chain for broken links. Inspect the sprockets for cracks and worn or damaged teeth. Replace all the components of the timing chain and sprocket assembly, if any one item needs replacement.

Inspect the fuel pump drive eccentric assembly for scores, nicks and excessive wear. If the eccentric is scored, replace it.

Timing Gears

Cleaning

Clean the gears in solvent and dry them with compressed air.

Inspection

Inspect the gear teeth for scores, nicks, etc. Note the condition of the teeth contact pattern. If the teeth are scored, replace the gears.

It is necessary to replace the gears in sets. Also, check backlash and runout.

Crankshaft Vibration Damper and Sleeve

Cleaning

Clean the oil seal contact surface on the crankshaft damper or sleeve with solvent to remove any corrosion, sludge or varnish deposits. Excess deposits that are not readily removed with solvent may be removed with crocus cloth. Use crocus cloth to remove any sharp edges, burrs, or other imperfections which might damage the oil seal during installation or cause premature seal wear. **Do not use crocus cloth to the extent that the seal surface becomes polished. A finely polished surface may produce poor sealing or cause premature seal wear.**

Inspection

Inspect the crankshaft damper or sleeve oil seal surface for nicks, sharp edges or burrs that might damage the oil seal during installation or cause premature seal wear.

Crankshaft

Cleaning

Handle the crankshaft with care to avoid possible fractures or damage to the finish surfaces. Clean the crankshaft with solvent, and blow out all oil passages with compressed air.

On a 4.9L engine, clean the oil seal contact surface at the rear of the crankshaft with solvent to remove any corrosion, sludge or varnish deposits. Excess deposits that are not readily removed with solvent may be removed with crocus cloth. Use crocus cloth to remove any sharp edges, burrs or other imperfections which might damage the oil seal during installation or cause premature seal wear. **Do not use crocus cloth to the extent that the seal surfaces become polished. A finely polished surface may produce poor sealing or cause premature seal wear.**

Inspection

Inspect the main and connecting rod journals for cracks, scratches, grooves or scores.

Measure the diameter of each journal in at least four places to determine out-of-round, taper or undersize condition (Fig. 35).

On an engine used with a manual shift transmission, check the fit of the clutch pilot bearing in the bore of the crankshaft. A needle roller bearing and adapter assembly is used as a clutch pilot bearing. It is inserted directly into the engine crankshaft. The bearing and adapter assembly cannot be serviced separately. The needle bearing clutch pilot can only be installed with the seal end of the bearing facing the transmission. The bearing and seal are pre-greased and do not require additional lubrication. A new bearing must be installed whenever a bearing is removed.

Inspect the pilot bearing, when used, for roughness, evidence of overheating or loss of lubricant. Replace if any of these conditions are found.

On the 4.9L (300 CID) I-6 engines, inspect the rear oil seal surface of the crankshaft for excessively deep grooves, nicks, burrs, porosity, or scratches which could damage the oil seal lip during installation. Remove all nicks and burrs and polish the chamfered edge and oil seal contact surface with crocus cloth.

Check the runout of the flywheel mounting flange with a Dial Indicator with Bracketry D78P-4201-F, -G or equivalent.

Flywheel

Automatic Transmission

Inspection

Inspect the flywheel for cracks or other damage that would make it unfit for further service. Inspect the starter ring gear for worn, chipped or cracked teeth. If the teeth are damaged, replace the flywheel assembly.

With the flywheel installed on the crankshaft, check the gear face runout of the flywheel. Refer to Diagnosis and Testing in this Section for the proper procedure.

Manual-Shift Transmission

Inspection

Inspect the flywheel for cracks, heat checks, or other damage that would make it unfit for further service. Machine the friction surface of the flywheel if it is scored or worn. If it is necessary to remove more than

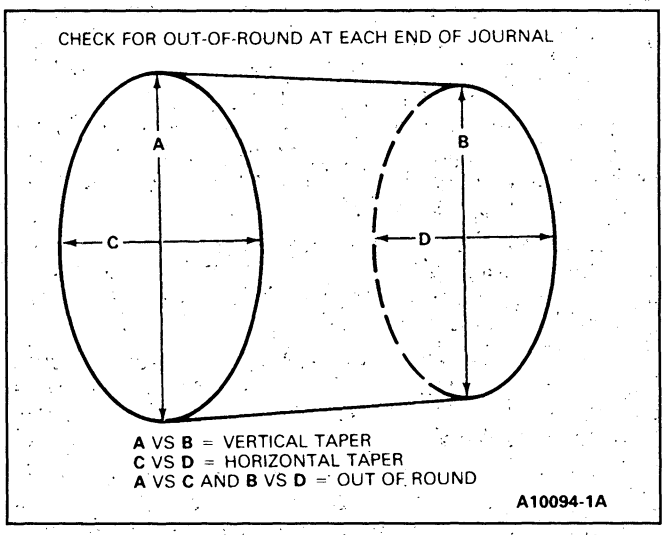


FIG. 35 Crankshaft Journal Measurement

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1.143mm (0.045 inch) of stock from the original thickness, replace the flywheel.

Inspect the ring gear for worn, chipped, or cracked teeth. If the teeth are damaged, replace the ring gear.

With the flywheel installed on the crankshaft, check the flywheel face runout following the procedure under Diagnosis and Testing in this Section.

Main and Connecting Rod Bearing

Cleaning

Clean the bearing inserts and caps thoroughly in solvent, and dry them with compressed air. **Do not scrape gum or varnish deposits from bearing shells.**

Inspection

Inspect each bearing carefully. Bearings with a scored, chipped, or worn surface must be replaced. Typical examples of bearing failure and the causes are shown in Fig. 36. The copper-lead bearing base may be visible through the bearing overlay in small localized areas. This may not mean that the bearing is excessively worn. **It is not necessary to replace the bearing if the bearing clearance is within recommended limits.** Check the clearance of bearings that appear to be satisfactory with Plastigage or its equivalent. Fit new bearings as outlined.

Connecting Rods

Cleaning

Remove the bearings from the rod and cap. Identify the bearings if they are to be used again. Clean the connecting rod in solvent, including the rod bore and the back of the bearing inserts. **Do not use a caustic cleaning solution. Blow out all passages with compressed air.**

Inspection

The connecting rods and related parts should be carefully inspected and checked for conformance to specifications. Various forms of engine wear caused by these parts can be readily identified as follows:

A shiny surface on the pin boss side of the piston usually indicates that a connecting rod is bent or the piston pin hole is not in proper relation to the piston skirt and ring grooves.

Abnormal connecting rod bearing wear can be caused by either a bent connecting rod, an improperly machined journal, or a tapered connecting rod bore.

Twisted connecting rods will not create an easily identifiable wear pattern, but badly twisted rods will disturb the action of the entire piston, rings, and connecting rod assembly and may be the cause of excessive oil consumption.

Inspect the connecting rods for signs of fractures. Inspect the bearing bores for out-of-round and taper. If the bore exceeds the maximum limit and/or if the rod is fractured, it should be replaced.

Check the ID of the connecting rod piston pin bore. Install oversize piston pin if the pin bore is not within specifications. Replace worn or damaged connecting rod nuts and bolts.

After the connecting rods are assembled to the piston, check the rods for bends or twists on a suitable alignment fixture. Follow the instructions of the fixture manufacturer. If the bend and/or twist exceeds specifications, the rod must be straightened or replaced.

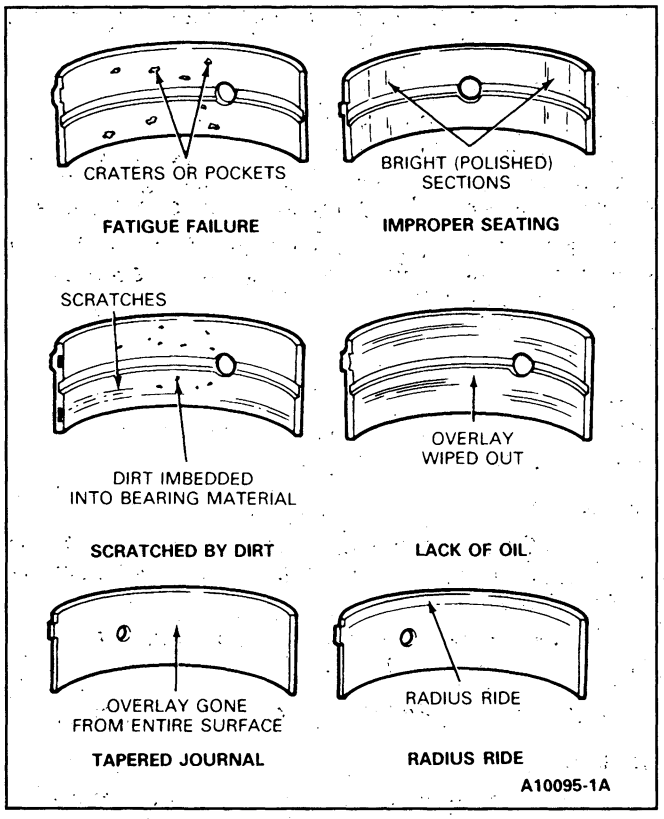


FIG. 36 Typical Bearing Failures

Pistons, Pins and Rings

Remove deposits from the piston surfaces. Clean gum or varnish from the piston skirt, piston pins and rings with solvent. **Do not use a caustic cleaning solution or a wire brush to clean pistons.** Clean the ring groove with Ring Groove Cleaner Tool D81L-6002-D (Fig. 37). Ensure the oil ring slots (or holes) are clean.

Inspection

Carefully inspect the pistons for fractures at the ring lands, skirts, and pin bosses, and for scuffed, rough, or scored skirts. If the lower inner portion of the ring grooves have high steps, replace the piston. The step will interfere with ring operation and cause excessive ring side clearance.

Spongy, eroded areas near the edge of the piston top are usually caused by detonation or pre-ignition. A shiny surface on the thrust surface of the piston, offset from the centerline between the piston pin holes, can be caused by a bent connecting rod. Replace pistons that show signs of excessive wear, wavy ring lands or fractures, or damage from detonation or pre-ignition.

Check the piston-to-cylinder bore clearance by measuring the piston and bore diameters. Refer to the specifications in the applicable engine section for the proper clearance. Refer to Cylinder Block Inspection for the bore measurement procedure. **Measure the OD of the piston with micrometers at the centerline of the piston pin bore and at 90 degrees to the pin bore axis. Check the ring side clearance following the procedure under Fitting Piston Rings.**

Replace piston pins showing signs of fracture, etching or wear. Check the piston pin fit in the piston

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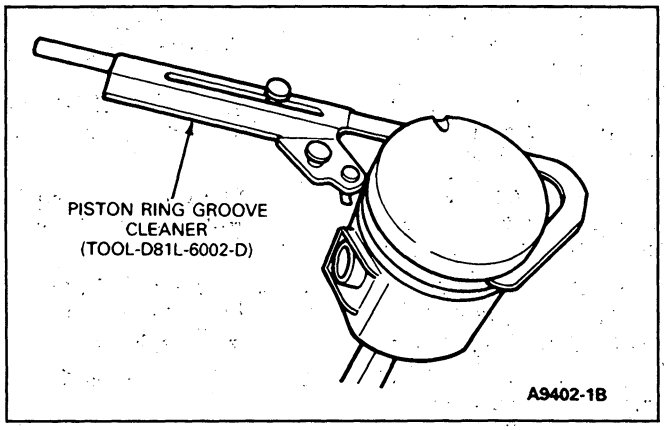


FIG. 37 Cleaning Ring Grooves—Typical

and rod. Refer to Piston and Connecting Rod Assemblies in the applicable engine section.

Check the OD of the piston pin and the ID of the pin bore in the piston. Replace any piston pin or piston that is not within specifications.

Replace all rings that are scored, chipped or cracked. Check the end gap and side clearance. It is good practice to always install new rings when overhauling an engine. Rings should not be transferred from one piston to another regardless of mileage.

Cylinder Block

Cleaning

After any cylinder bore repair operation, such as honing or deglazing, clean the bore(s) with soap or detergent and water. **Then, thoroughly rinse the bore(s) with clean water to remove the soap or detergent, and wipe the bore(s) dry with a clean, lint-free cloth. Finally, wipe the bore(s) with a clean cloth dipped in engine oil. If these procedures are not followed, rusting of the cylinder bore(s) may occur.**

If the engine is disassembled, thoroughly clean the block in solvent. Remove old gasket material from all machined surfaces. Remove all pipe plugs sealing oil passages; then clean out all the passages. Blow out all passages, bolt holes, etc., with compressed air.

Ensure the threads in the cylinder head bolt holes are clean. Dirt in the threads may cause binding and result in a false torque reading. Use a tap to true-up threads and to remove any deposits.

Inspection

After the block has been thoroughly cleaned, check it for cracks. Minute cracks not visible to the naked eye may be detected by coating the suspected area with a mixture of 25 percent kerosene and 75 percent light engine oil. Wipe the part dry and immediately apply a coating of zinc oxide dissolved in wood alcohol. Avoid use of methanol substitute rubbing alcohol. If cracks are present, the coating will become discolored at the cracked area. Replace the block if it is cracked.

Check all machined gasket surfaces for burrs, nicks, scratches and scores. Remove minor imperfections with an oil stone such as D81L-6002-A or equivalent. Check the cylinder block for flatness of the cylinder head gasket surface following the procedure and specifications recommended for the cylinder head. The cylinder block can be machined to bring the cylinder head gasket surface within the flatness specifications listed in the specific engine Section. **Do not to exceed 0.254mm (0.010 inch) stock removal from the original gasket surface.**

Replace all expansion-type plugs showing evidence of leakage.

Inspect the cylinder walls for scoring, roughness, or other signs of wear. Check the cylinder bore for out-of-round and taper. Measure the bore with an accurate bore gauge following the instructions of the manufacturer. Measure the diameter of each cylinder bore at the top, middle and bottom with the gauge placed at right angles and parallel to the centerline of the engine (Figs. 24 and 25). Use only the measurements obtained at 90 degrees to the engine centerline when calculating the piston-to-cylinder bore clearance.

Refinish cylinders that are deeply scored and/or when out-of-round and/or taper exceed(s) the service limits.

If the cylinder walls have minor surface damage, but the out-of-round and taper are within limits, it may be possible to remove such damage by honing the cylinder walls and installing new service piston rings providing the piston clearance is within specified limits listed in the specific engine Section.

To remove the cylinder wall glaze or to refinish a cylinder bore, follow the honing procedure described under Cylinder Block-Refinishing Cylinder Walls.

Oil Pan

Cleaning

Scrape any dirt or metal particles from the inside of the pan. Scrape all old gasket material from the gasket surface. Wash the pan in solvent and dry it thoroughly. Be sure all foreign particles are removed from below the baffle plate.

Inspection

Check the pan for cracks, holes, damaged drain plug threads, and a loose baffle. Check the gasket surface for damage caused by over-tightened bolts. Straighten the surface as required to restore original flatness.

Replace the pan if repairs cannot be made.

Oil Pump

Cleaning

Wash all parts in a solvent and dry them thoroughly with compressed air. Use a brush to clean the inside of the pump housing and the pressure relief valve chamber. Ensure all dirt and metal particles are removed.

Inspection

Refer to the Specifications in the applicable engine section for clearances and service limits.

Check the inside of the pump housing and the outer race and rotor for damage or excessive wear or scoring.

Check the mating surface of the pump cover for wear. If the cover mating surface is worn, scored or grooved, replace the pump.

Measure the inner rotor tip clearance (Fig. 38).

With the rotor assembly installed in the housing, place a straightedge over the rotor assembly and the housing. Measure the clearance (rotor end play)

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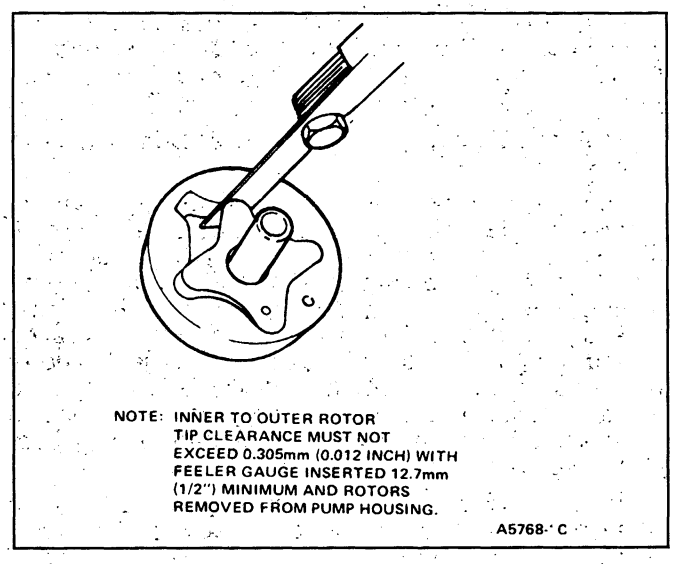


FIG. 38 Checking Inner Rotor Tip Clearance

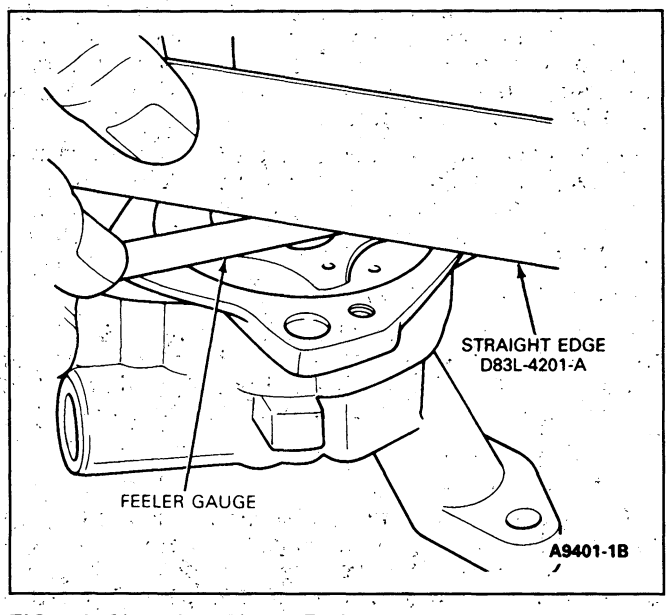


FIG. 39 Checking Rotor End Play

between the straightedge and the rotor and outer race (Fig. 39). Refer to the specific engine Section for specification.

Check the drive shaft-to-housing bearing clearance by measuring the OD of the shaft and the ID of the housing bearing.

Detail components of the oil pump are not serviced. If any part of the oil pump requires replacement, replace the complete pump assembly.

Inspect the relief valve spring for a collapsed or worn condition. Check the relief valve spring tension according to specifications for specific engine.

Check the relief valve piston for scores and free operation in the bore.

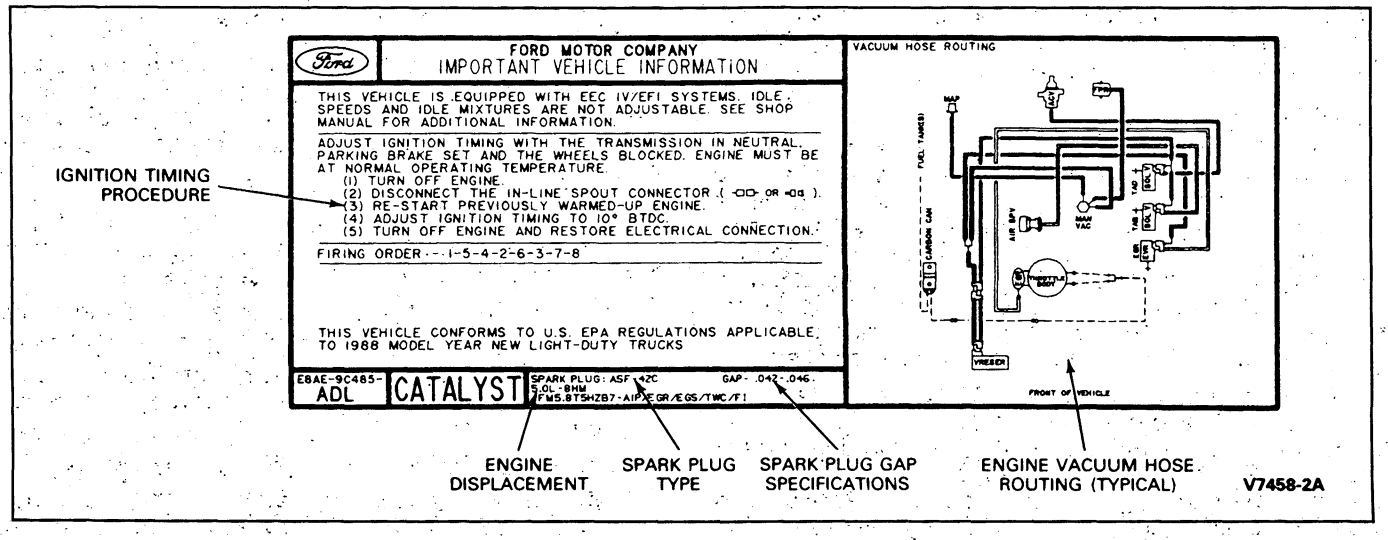


FIG. 40 Typical Vehicle Emission Control Information (VECI) Decal

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SPECIFICATIONS

Engine Displacement	APPROXIMATE ENGINE OIL CAPABILITY					
	U.S. Quarts With Filter Change	U.S. Quarts Without Filter Change	Imp. Quarts With Filter Change	Imp. Quarts Without Filter Change	Liters With Filter Change	Liters Without Filter Change
4.9L (300 CID) I-6	6	5	5	4.1	5.6	4.7
5.0L (302 CID) V-8	6	5	5	4.1	5.6	4.7
5.8L (351 CID) W-V-8	6	5	5	4.1	5.6	4.7
7.5L (460 CID) V-8	6	5	5	4.1	5.6	4.7

CA1415-2J

SPECIAL SERVICE TOOLS

GENERAL GASOLINE ENGINE SERVICE

Tool Number	Description	Tool Number	Description
D79P-100-A	Impact Slide Hammer	T00L-6331	Upper Main Bearing Insert Remover & Replacer
T50T-100-A	Impact Slide Hammer	T74P-6375-A	Flywheel Holding Tool
T59L-100-B	Impact Slide Hammer	T00L-6500-E	Hydraulic Tappet Leakdown Tester
T58L-101-B	Puller Attachment	T00L-6505-E	Valve Stem Clearance Tool
T72J-1177	Bearing Housing Seal Replacer	T65P-6513-A	Valve Spring Compressor
T75L-4201-A & -B	Clutch Housing Alignment Adapter	T70P-6513-A	Tappet Bleed Down Wrench
D78P-4201-B	Dial Indicator with Mag. Base	T71B-6513-B	Tappet Bleed Down Wrench
D78P-4201-F, G	Dial Indicator with Bracketry	T71P-6513-B	Tappet Bleed Down Wrench
T00L-4201-C	Dial Indicator with Bracketry	T00L-6513-DD	Valve/Clutch Spring Tester
T70P-6000	Engine Lifting Brackets	T00L-6513-K	Tappet Bleed Down Wrench
T75T-6000-A	Engine Lifting Plate	T79T-6527-A	Rocker Arm Stud Remover
D81L-6002-D	Piston Ring Groove Cleaner	T79T-6527-B	Rocker Arm Stud Replacer
D81P-6002-E	Valve Seat Runout Gauge	T62F-6565-A	Valve Spring Compressor
T64L-6011-EA	Cylinder Ring Reamer	T00L-6565-AB	Cup Shaped Adapter
T73L-6011-A	Cylinder Hone Set	T73L-6600-A	Pressure Gauge
T61P-6019-B	Front Cover Aligner	D79P-6666-A	Spark Plug Boot Puller
T68P-6019-A	Front Cover Aligner	T74P-6666-A	Spark Plug Wire Remover
T79T-6019-A	Front Cover Aligner	T65P-6701-A	Rear Oil Seal Replacer
T69P-6049-D	Rocker Arm Stud Replacer	D79L-6731-A	Oil Filter Wrench
T70P-6049-A	Valve Spring Compressor	D79L-6731-B	Oil Filter Wrench
T79T-6070-A	Front Seal Remover Adapters	T70P-6B070-A	Front Cover Seal Replacer
T68P-6135-A	Piston Pin Remover/Replacer	T70P-6B070-B	Front Cover Seal Remover
T65L-6250-A	Camshaft Bearing Set	T62F-6A527-B3, B5	Rocker Arm Stud Replacer
T52L-6306-AEE	Crankshaft Damper & Sprocket Replacer	T77L-9533-B	Jet Plug Puller
T58T-6306-A	Crankshaft Sprocket Remover	D81L-6002-A	Oil Stone
T65L-6306-A	Camshaft Gear Replacing Adapter	D81L-6002-B	Plastigage
T58P-6316-D	Crankshaft Damper Remover	D83L-4201-A	Straight Edge
T79T-6316-A	Damper Remover/Replacer Tool		

CA6855-2H

ROTUNDA EQUIPMENT

Model Number	Description
112-00001	Blacklight Oil Leak Detector①②
014-00705	Engine Cylinder Leak Detection and Air Pressurization Kit

①Use with Ford specification, ESE-M99C103-A Fluorescent Oil Additive.
②Use with Rotunda specification, 112-00005 Fluorescent Oil Additive.

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VEHICLE APPLICATION

E-150 Through E-350, F-150 Through F-350 and Bronco Truck Models.

DESCRIPTION

Engine

The 4.9L (300 CID) I-6 engine block is a special high-grade cast iron. The crankshaft has seven main bearings and is made of precision cast nodular iron. Pistons are aluminum alloy with integral steel struts. The valve rocker arms are stamped steel with powdered metal cylindrical fulcrums. Tappets are hydraulic and are self-adjusting. The 4.9L (300 CID) I-6 engine has exhaust valve rotators. Timing gears are helical gear type. The cam gear is made of phenolic material.

The 4.9L (300 CID) I-6 is the standard engine for E-150—E-350, Bronco, F-150—F-350 and F-150—F-250 (4x4)

Engine Code Information Label

Refer to Fig. 1.

Located on the timing gear front cover is the engine code information label containing, among other pertinent data, an engine build date, an engine plant code, and an engine code.

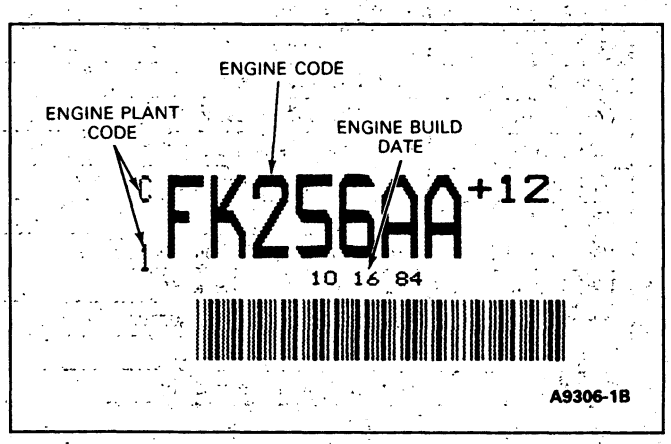


Fig. 1 4.9L Engine Code Label

Emission Calibration Label

Refer to Fig. 2. The emission calibration number label is located on the LH side door or LH door post pillar. It identifies the engine calibration number, the engine code number and revision level.

These numbers are used to determine if parts are unique to specific engines.

NOTE: It is imperative that the engine codes and the calibration number be used when ordering parts or making inquiries about the engine.

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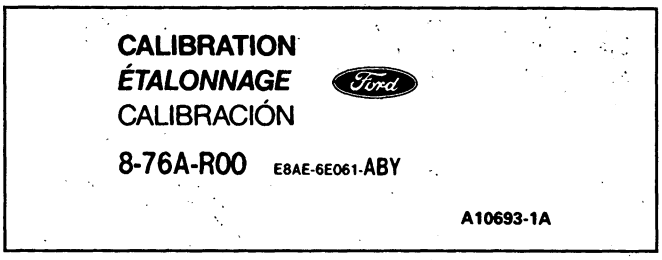


FIG. 2 Emission Calibration Label

Exhaust Emission Control System

Refer to Fig 1.

The exhaust emission control devices used on these engines are covered in the Engine/Emissions Diagnosis* manual.

Crankcase Ventilation System

These engines are equipped with a positive, closed-type ventilation system which directs the crankcase vapors to the intake manifold for combustion.

Lubrication System

Oil from the oil pan sump is forced through the pressure-type lubrication system by a rotor-type oil pump (Fig. 3). A spring-loaded relief valve in the pump limits the maximum pressure of the system. Oil relieved by the valve is directed back to the intake side of the pump.

The engine has a full-flow disposable filter or a replaceable element-type filter which filters the entire output of the pump before the oil enters the engine. The filters have an integral relief valve. The relief valve permits oil to bypass the filter if it becomes clogged, thereby maintaining a continuous supply of oil to the engine. An anti-drain back feature is designed into the oil filter system to prevent a reverse flow of oil when the engine is stopped.

From the filter, the oil flows into the main oil gallery. The oil gallery supplies oil to all the camshaft and main bearings.

The crankshaft is drilled from the main bearings to the connecting rod journals to lubricate the rod bearings.

Oil from the floor of the valve tappet chamber is fed through a drilled passage in the cylinder block into the distributor pilot to lubricate the distributor shaft, bushings, and the distributor-to-oil pump intermediate shaft engagement.

The main oil gallery intersects all of the valve tappet bores supplying pressurized oil to the hydraulic valve tappets. A reservoir at each valve tappet bore boss traps oil so that oil is available for valve tappet lubrication as soon as the engine starts.

When the hydraulic tappet is on the base circle of the camshaft lobe (valve closed), the oil hole in the hydraulic tappet is indexed with the oil gallery, and oil flows into the plunger. Oil is also metered through the metering valve (disc) through the oil passages in the push rod cup and it flows up the hollow push rod. In this position, the drilled hole in the ball end of the push rod is indexed with a drilled hole in the rocker arm, and the oil lubricates the upper valve train bearing areas. Excess oil is returned to the oil pan through drain holes along the side of the cylinder head and block.

Excess oil in the push rod chamber drains back into the oil pan through openings along the cylinder block.

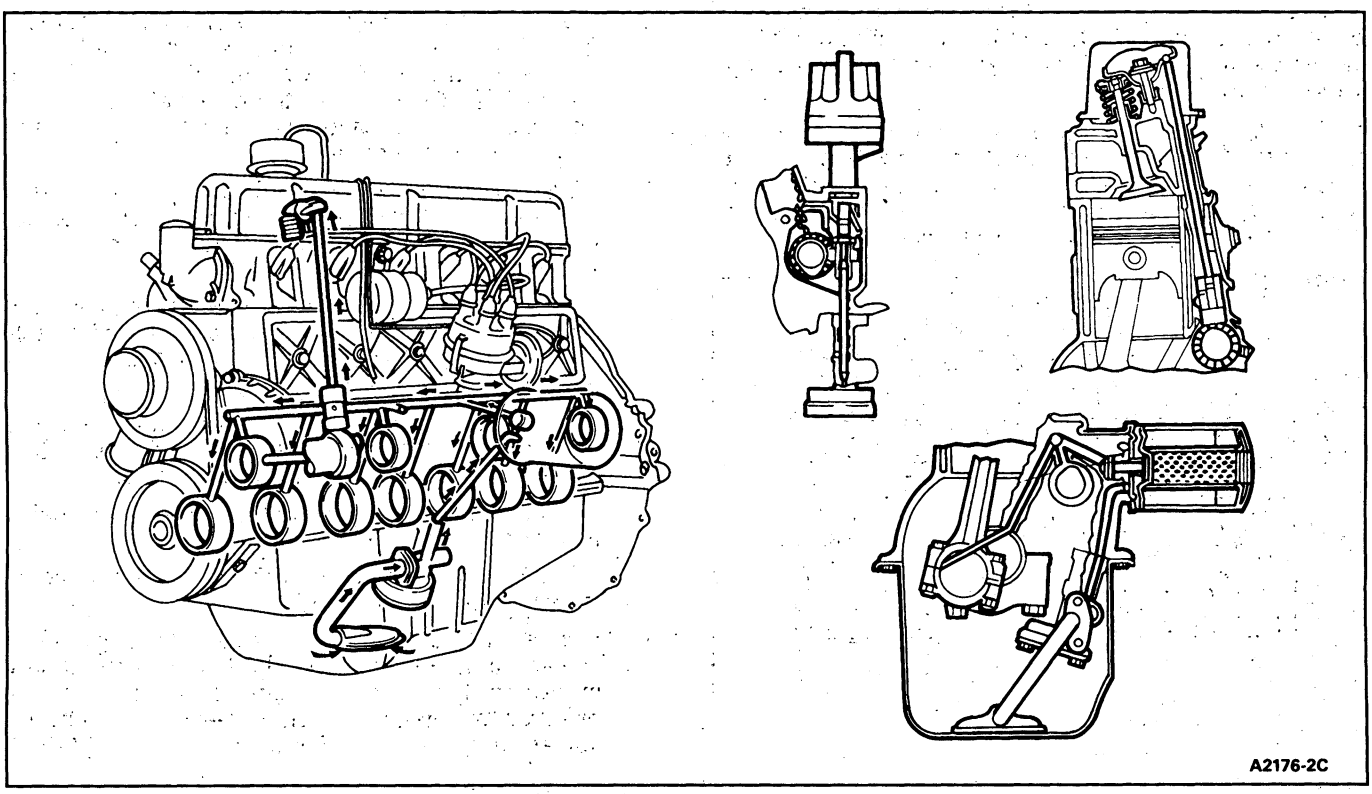


FIG. 3 Typical Lubrication System

*Can be purchased as a separate item.

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Cooling System

The coolant is drawn from the bottom of the radiator by the water pump, which delivers the coolant to the cylinder block (Fig. 4).

As the coolant enters the block, it travels through cored passages to cool the entire length of each cylinder wall. The coolant is then directed upward into the cylinder head where it cools the combustion chambers, valves and valve seats.

The coolant from the cylinder head flows into the coolant outlet housing, past the thermostat if it is open, and into the top of the radiator. If the thermostat is closed, a small portion of the coolant is returned to the water pump for recirculation.

DIAGNOSIS AND TESTING

Refer to Diagnosis and Testing in Section 21-01, General Gasoline Engine Service.

ADJUSTMENTS

Valve Clearance

A 1.52mm (0.060 inch) shorter push rod or a 1.52mm (0.060 inch) longer push rod is available for service to provide a means of compensating for dimensional changes in the valve mechanism. Refer to the Master Parts List or the specifications for the appropriate color code.

Valve stem-to-valve rocker arm clearance should be within specifications with the hydraulic tappet completely collapsed. Repeated valve reconditioning operations (valve and/or valve seat refacing) will decrease the clearance to the point that if it is not compensated for, the hydraulic valve tappet will collapse and cease to function, and could prevent the valve seat face from properly seating on the valve seat. Valve will be held open.

The positive stop rocker arm bolt eliminates the necessity of adjusting the valve clearance. However, to obtain the specified valve clearance, it is important that all valve components be in a serviceable condition and installed and tightened to specification.

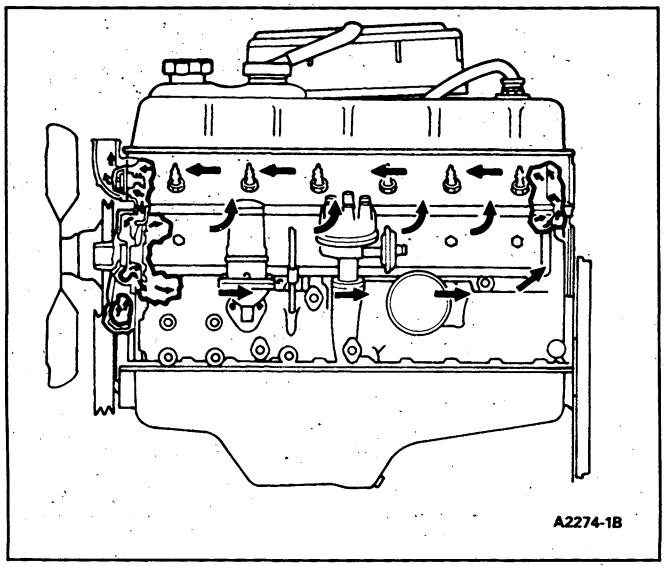


FIG. 4 Engine Coolant Flow Typical

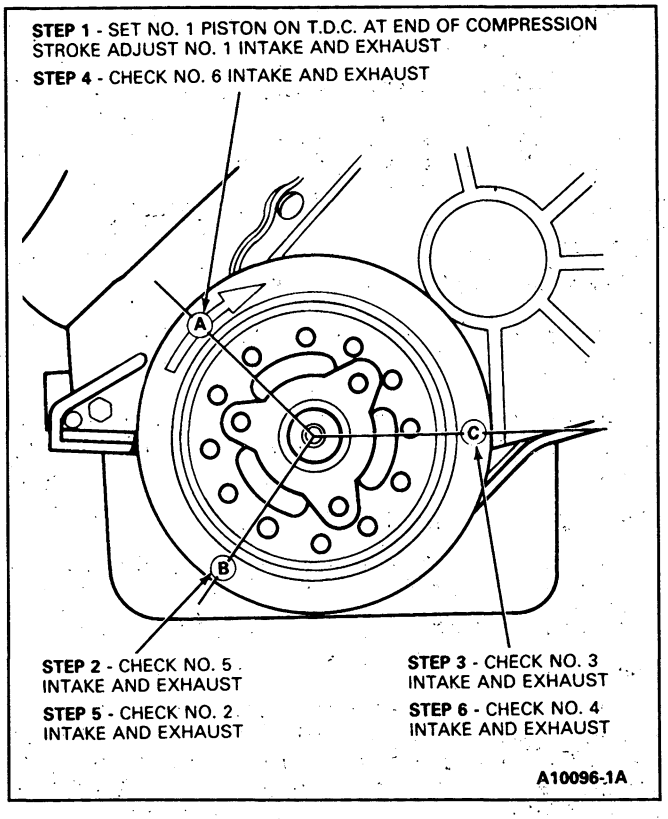


FIG. 5 4.9L (300 CID) Six Valve Clearance

To determine whether a shorter or a longer push rod is necessary, make the following check.

1. Install an auxiliary starter switch. **Crank the engine with the ignition switch in OFF position.**
2. Make two chalk marks on the crankshaft damper (Fig. 5). Space the marks approximately 120 degrees apart so that, with the timing mark, the damper is divided into three equal parts (120 degrees is one-third of the distance around the damper circumference).
3. With No. 1 piston on TDC at the end of the compression stroke, tighten the rocker arm bolts of the No. 1 intake and exhaust valves to specifications.

   Then slowly supply pressure to bleed down the hydraulic tappet until the plunger is completely bottomed using Tappet Bleed Down Wrench T70P-6513-A or equivalent (Fig. 6).

   Hold the tappet in this position and check the available clearance between the rocker arm and the valve stem tip with a feeler gauge.

   If the clearance is less than specifications, install a shorter push rod.

   If the clearance is greater than specifications, install a longer push rod.
4. Repeat this procedure for the remaining set of valves, turning the crankshaft with an auxiliary starter switch, one-third turn at a time, in the direction of rotation. At the same time, adjust the valves in the firing order sequence, 1-5-3-6-2-4.

REMOVAL AND INSTALLATION

When installing nuts or bolts that must be tightened, oil the threads with light weight engine oil. **Do not oil**

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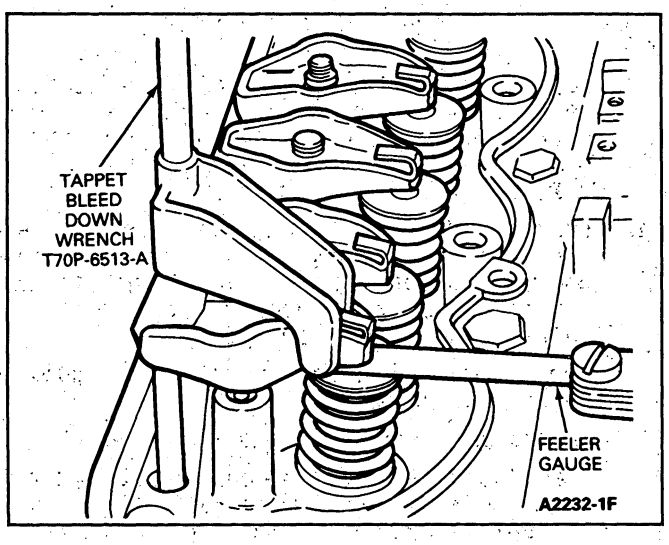


FIG. 6 Valve Clearance Check

threads that require oil-resistant or water-resistant sealer.

Refer to Section 21-01, General Gasoline Engine Service for Repair and Cleaning and Inspection procedures. Refer to the end of this Section for all engine component bolt torque specifications. Refer to Section 27-06, Accessory Drive Belt Service for all belt tension specifications.

Engine Assembly

F-150—F-350 and Bronco

The engine removal and installation procedures are for the engine only without the transmission attached.

Removal

1. Drain the cooling system and the crankcase. Remove the hood. Remove the throttle body inlet tubes.
2. Disconnect the battery ground cable. Disconnect the heater hose from the water pump and coolant outlet housing. Disconnect the flexible fuel line from the fuel pump.
3. Remove the radiator. Refer to Section 27-04, Radiators
4. Remove the cooling fan, viscous fan drive, water pump pulley and fan drive belt (Fig. 7).

NOTE: The fan clutch/water pump hub has a RH thread.

5. Disconnect the accelerator cable at the throttle body. Remove the cable retracting spring.

   Disconnect power brake vacuum line at the intake manifold.

   On a vehicle with an automatic transmission, disconnect the transmission kickdown cable at the throttle body.
6. Disconnect the exhaust manifold from the muffler inlet pipe. Disconnect the body ground strap and the battery ground cable at the engine.
7. Disconnect the Electronic Engine Control (EEC) harness from all sensors (if so equipped).
8. Disconnect the engine wiring harness at the ignition coil, coolant temperature sending unit and oil pressure sending unit. Position the harness out of the way.

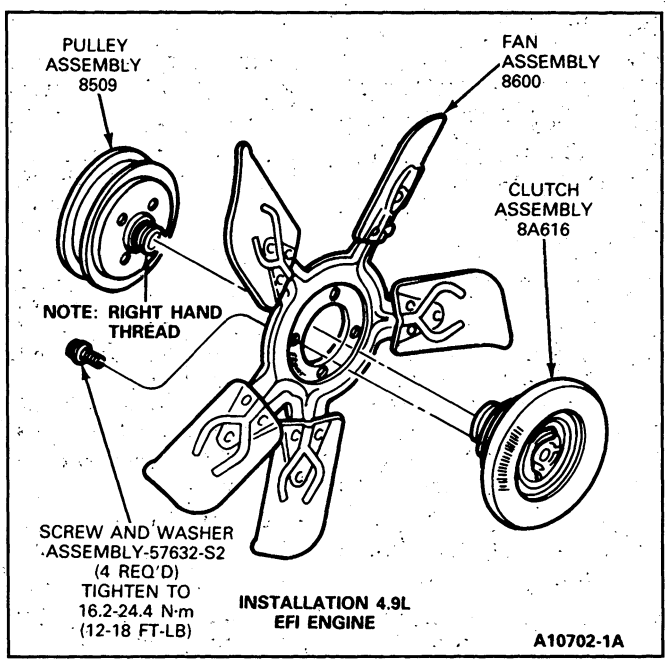


FIG. 7 Fan Blade Installation F-150—F-350, E-Series and Bronco

9. Remove the alternator mounting bolts and position the alternator out of the way, leaving the wires attached.

   Remove the power steering pump from the mounting brackets and position it right side up and to one side, leaving the lines attached. If equipped with an air compressor, bleed the air system and disconnect the two air pressure lines at the compressor.
10. Raise the vehicle. Remove the starter (and the automatic transmission fluid filler tube bracket). Remove the engine rear plate upper RH bolt.

    On a vehicle with a manual transmission, remove all the flywheel housing lower attaching bolts. Disconnect the clutch retracting spring.

    On a vehicle with an automatic transmission, remove the converter housing access cover assembly. Remove the flywheel-to-converter nuts and secure the converter assembly in the housing. Remove the transmission oil cooler lines from the retaining clip at the engine. Remove the converter housing-to-engine lower attaching bolts.
11. On F-150—F-350 and Bronco, remove the insulator-to-intermediate support bracket nut from each engine front support.
12. Lower the vehicle and position a transmission jack, such as Rotunda 066-00017 or equivalent, under the transmission to support it. Remove the remaining flywheel or converter housing-to-engine bolts.
13. Attach Engine Lifting Bracket T70P-6000 or equivalent. Raise the engine slightly and carefully pull it from the transmission. Lift the engine out of the chassis.

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Installation

1. Lower the engine carefully into the chassis. Make sure the dowels in the block engage the holes in the flywheel or converter housing.

   On a vehicle with an automatic transmission, start the converter pilot into the crankshaft. Remove the retainer securing the converter in the housing.

   On a vehicle with a manual transmission, start the transmission input shaft into the clutch disc. It may be necessary to adjust the position of the transmission with relation to the engine if the transmission input shaft will not enter the clutch disc. **If the engine hangs up after the shaft enters, turn the crankshaft slowly (with the transmission in gear) until the shaft splines mesh with the clutch disc splines.**
2. Install the converter or flywheel housing upper attaching bolts. Remove the jack supporting the transmission.
3. Lower the engine until it rests on the engine support(s) and remove the lifting sling.
4. Install the engine LH and RH, support insulator-to-intermediate support bracket attaching nuts and washers. Tighten the nuts to 73-100 N·m (54-74 ft-lb). Install the automatic transmission oil cooler lines bracket.
5. Install the remaining converter or flywheel housing attaching bolts. Connect the clutch return spring.
6. Install the starter and connect the starter cable. Attach the automatic transmission fluid filler tube bracket, if so equipped.

   On a vehicle with an automatic transmission, install the transmission oil cooler lines in the bracket at the cylinder block.
7. Install the exhaust manifold-to-muffler inlet pipe lockwashers and nuts. Tighten the nuts to specification. Refer to Section 26-01, General Exhaust Systems Service.
8. Connect the engine ground strap and the battery ground cable.
9. Connect Electronic Engine Control (EEC) harness to all sensors, if so equipped.
10. On a vehicle with an automatic transmission, connect the kickdown cable to the throttle body.

    Connect the accelerator linkage to the throttle body and install the retracting spring.

    Reconnect power brake vacuum line to the intake manifold.
11. Connect the coil primary wire, oil pressure and coolant temperature sending unit wires, flexible fuel line, heater hoses and the battery positive cable.
12. Install the alternator on the mounting bracket.

    Install power steering pump on the mounting brackets.
13. Install the water pump pulley, viscous fan drive, cooling fan and drive belt. Tighten the fan bolts to 17-24 N·m (12-18 ft-lb) (Fig. 6).

    NOTE: The fan clutch/water pump hub has a RH thread.

    Adjust tension of all drive belts to specification. Tighten the alternator, power steering pump and air compressor mounting bolts to specification. Refer to Section 27-06, Accessory Drive Belt Service.
14. Install the radiator. Connect the radiator lower hose to the water pump and the radiator upper hose to the coolant outlet housing. Connect the air compressor lines. If removed, install air conditioner compressor and condenser.

    On a vehicle with an automatic transmission, connect the oil cooler lines.
15. If applicable, install and adjust the hood.
16. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service. Fill the crankcase. Operate the engine at fast idle and check all hose connections and gaskets for leaks.
17. Perform EEC Quick Test to check the function of the EEC system, if so equipped. Refer to Engine/Emissions Diagnosis* manual.
18. On a vehicle with a manual transmission, adjust the clutch pedal free travel. Refer to Section 16-03, Mechanical Clutch Linkage.

    On a vehicle with an automatic transmission, adjust the transmission control linkage. Refer to Section 17-02, Shift Control Linkage. Check the fluid level and add as required to bring it to the proper level on the oil indicator.
19. Install the throttle body intake tubes.

E-150—E-350

Removal

1. Open the hood and door and install seat covers. Then, remove the engine cover, drain the coolant, remove the air cleaner and disconnect the battery.
2. Remove the front bumper. Then, remove the grille and lower gravel deflector as an assembly.
3. Disconnect the upper radiator hose at the radiator.
4. Remove the lower radiator hose at the radiator.
5. Disconnect the transmission oil cooler lines at the radiator, if so equipped.
6. Remove the radiator and the shroud, if so equipped.
7. Disconnect the heater hoses at the engine.
8. Disconnect the alternator and move aside.
9. Remove the power steering pump drive belt. Then, remove the power steering pump and support from the engine and move aside.
10. Disconnect the fuel line at the fuel rail and plug it.
11. Disconnect the distributor and sender unit wires from the engine.
12. Disconnect the Electronic Engine Control (EEC) harness from all sensors, if so equipped.
13. Disconnect the brake booster hose at the engine.
14. Disconnect the accelerator cable and remove the bracket from the engine.

*Can be purchased as a separate item.

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15. Disconnect the automatic transmission kickdown cable at the throttle body.
16. Remove the exhaust manifold heat deflector. Then, remove the inlet pipe-to-manifold nuts.
17. Disconnect both ends of the transmission vacuum line from the intake manifold and junction.
18. Remove the upper transmission-to-engine bolts.
19. Remove the automatic transmission dipstick tube support bolt at the intake manifold.
20. Raise the vehicle on a hoist and drain the crankcase.
21. Disconnect the wires from the starter and remove the starter.
22. Remove the flywheel inspection cover.
23. Remove the four converter nuts, then remove the front engine support nuts.
24. Remove the oil filter.
25. Complete the removal of the engine-to-transmission nuts.
26. Lower the vehicle.
27. Install the lift chain and remove the engine from the engine compartment.

Installation

1. Position the engine and lower into place. Then, start the mounting bolts.
2. Remove the lifting chain and connect the exhaust inlet to the manifold.
3. Connect the transmission dipstick tube, if so equipped, to the intake manifold.
4. Install the manifold heat shield.
5. Connect the automatic transmission kickdown cable, then install the upper transmission-to-engine bolts.
6. Connect the transmission vacuum line at the junction.
7. Install the accelerator cable and bracket assembly.
8. Connect the distributor and sender unit wires to the engine.
9. Connect the brake booster hose.
10. Unplug and connect the fuel line to the fuel rail.
11. Connect the transmission vacuum line to the manifold.
12. Install the alternator wires.
13. Connect the heater hoses to the engine.
14. Install the power steering pump and support bracket.
15. Install and adjust the power steering pump belt for the proper tension. Refer to Section 27-06, Accessory Drive Belt Service.
16. Install the radiator and shroud assembly, if so equipped.
17. Position the grille and lower gravel deflector.
18. Connect the upper radiator hose, then install the grille and deflector bolts and screws.
19. Install the bumper, then raise the vehicle on a hoist.
20. Install the converter nuts, then install the flywheel inspection cover bolts.
21. Connect the starter wires and install the starter assembly.
22. Install the oil filter.
23. Install the front support nuts, and the lower engine-to-transmission bolts. Tighten to 82-108 N·m (60-80 ft-lb).
24. Connect the lower radiator hose.
25. Connect the transmission cooler lines to the radiator.
26. Install the alternator splash shield.
27. Lower the vehicle.
28. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service. Connect the battery and fill the crankcase with the proper grade of oil.
29. Perform the EEC Quick Test to check the function of the EEC system, if so equipped. Refer to the Engine/Emissions Diagnosis* manual.
30. Start the engine and check for leaks. Then, install the engine cover and close the hood and door.

Engine Front Supports

The 4.9L (300 CID) I-6 engine for F-150—F-350, Bronco, E-150—E-350 is mounted on three engine mounts. These models have two front mounts located on each side of the engine and one rear mount located on the transmission extension housing.

The mounts and their applications are shown in Figs. 8, 9 and 10.

E-150—E-350

Removal

1. Raise the vehicle on a hoist.
2. Remove the front support insulator-to-support bracket nuts and washers from both insulators (Fig. 8).
3. Place a Rotunda Transmission Jack 066-00017 or equivalent under the engine oil pan and position a wood block between the jack and oil pan. Raise the engine just enough to take the weight off the support brackets.
4. The support brackets are mounted to the front frame crossmember with four bolts and locknuts. If these are to be removed, loosen the four locknuts on each support bracket and remove from the crossmember.
5. Remove the insulator assembly-to-cylinder block bolts and remove the front support insulators.

Installation

1. Install the insulators on the engine block and tighten the bolts to 81-108 N·m (60-80 ft-lb).
2. Install the four bolts and locknuts on the front crossmember support brackets. Tighten to 81-108 N·m (81-108 ft-lb).

*Can be purchased as a separate item.

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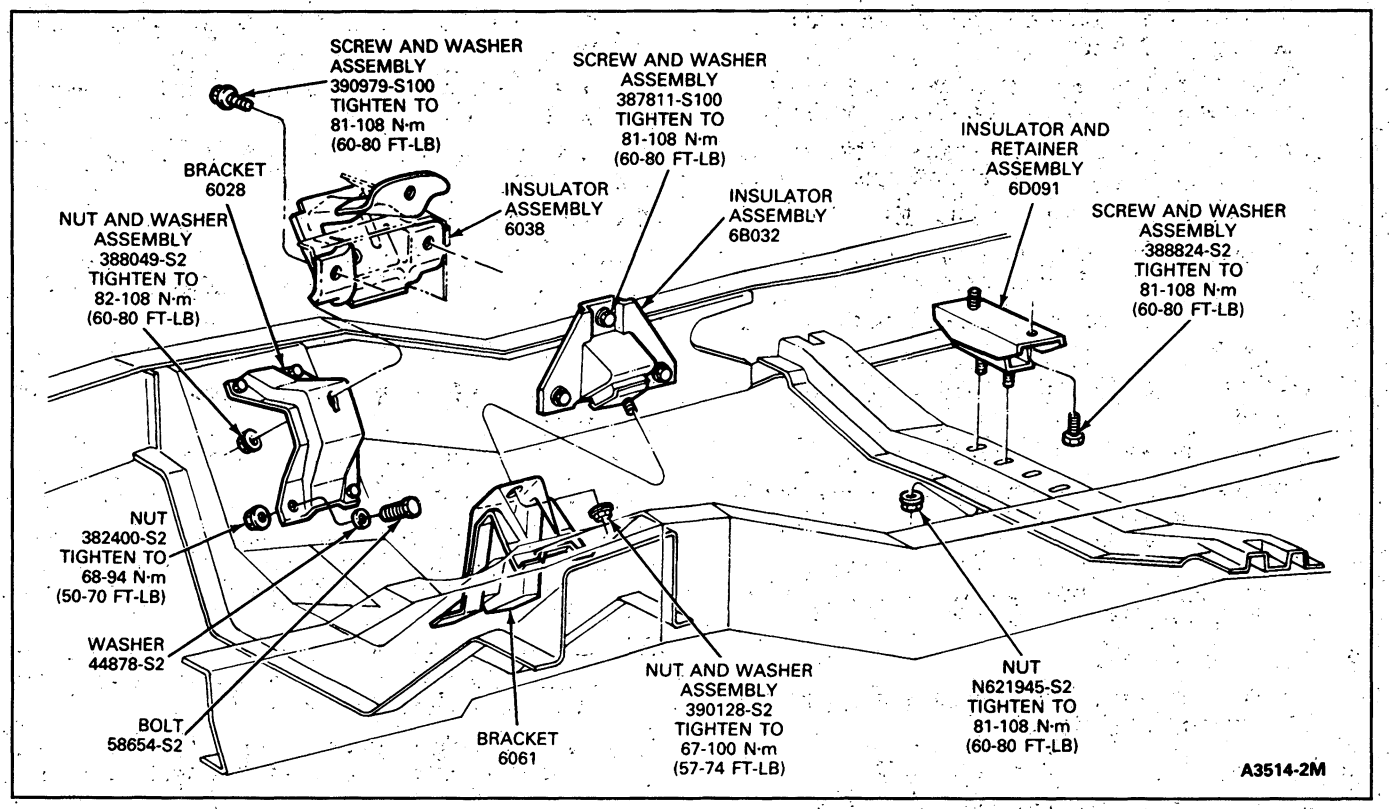


FIG. 8 Engine Supports—E-150—E-350

3. Lower the engine until the front support insulators engage the support brackets. Remove the transmission jack.
4. Install the front support insulator-to-support bracket nuts and washers. Tighten the nuts to 67-100 N·m (57-74 ft-lbs).
5. Lower the hoist.

Double Front Mount F-150—F-250 and Bronco

The following procedures apply to either a RH or LH installation (Fig. 9).

Removal

1. Remove the upper and lower nut and washer assemblies from the insulator assembly. If only one insulator is being removed, loosen nut and washer assemblies on opposite insulator.
2. Using a jack and a wood block placed under the oil pan, raise the engine to allow just enough clearance for removal of the mount.
3. Remove the RH or LH mount, and shield (RH mount only).
4. Remove three bolts securing upper bracket.
5. Remove nuts and bolts securing lower bracket.

Installation

1. Position the lower bracket and install new bolts and nuts. Tighten to 65-85 N·m (48-62 ft-lb) (Fig. 9).
2. Position upper bracket and install bolts. Tighten to 80-110 N·m (59-81 ft-lb).
3. Align locator pin with hole and position insulator on lower bracket.
4. Install lower nut and washer assembly finger tight.
5. On RH insulator, position shield.
6. Lower the engine carefully to make sure the insulator stud and pin engage the upper bracket mounting hole.
7. Install the nut and washer on the upper insulator stud. Tighten the upper and lower stud nuts to 96-127 N·m (71-93 ft-lb).
8. If only one insulator was removed, tighten the other insulator at the support brackets.

Engine Rear Supports

F-150—F-350 and Bronco

Removal

1. Remove the attaching bolts, nut and washers (Fig. 10).
2. Raise the transmission slightly to provide clearance and remove the insulator and insulator retainer.

Installation

1. Position the insulator and retainer (Fig. 10).

   Install the insulator-to-extension housing, lockwashers and bolts.
2. Lower the transmission and install the insulator-to-frame crossmember bolt. Tighten the nut and bolts to specifications.

E-150—E-350

Removal

1. Raise the vehicle on a hoist. Place a transmission jack, such as Rotunda 066-00017 or equivalent, under the transmission and raise it slightly so the

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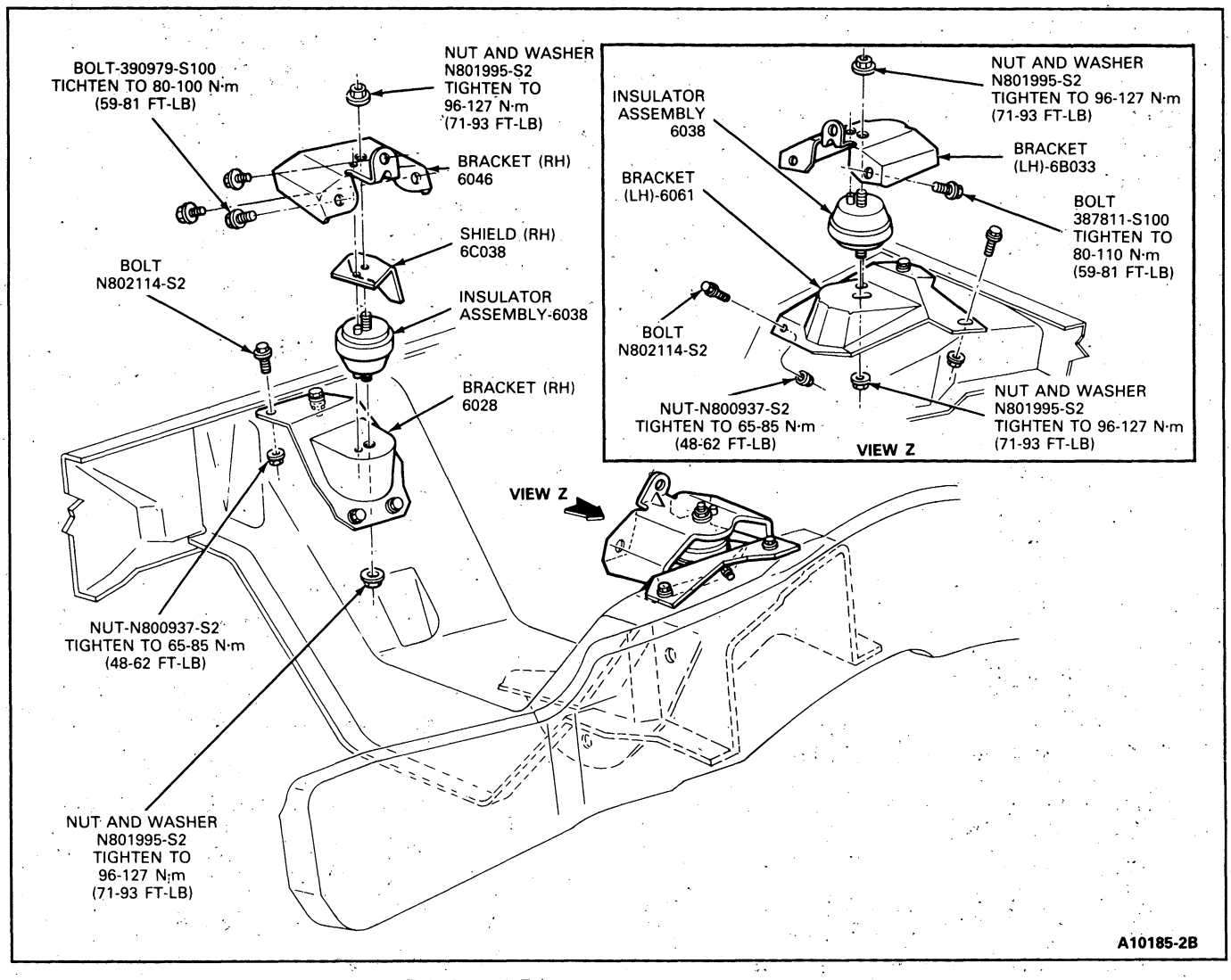


FIG. 9 Engine Front Mounts—F-150—F-350 and Bronco

transmission weight is not supported by the rear support insulator.

2. Remove the insulator-to-crossmember and transmission extension housing locknuts and bolts (Fig. 8).
3. Remove the rear support insulator.

Installation

1. Position the rear support insulator between the transmission extension housing and vehicle crossmember. Refer to Fig. 10 for the proper position of the support insulator.
2. Install the support insulator attaching bolts and locknuts. Tighten the locknuts to 68-94 N·m (50-70 ft-lb).

WARNING: ON 138 INCH WHEEL BASE VEHICLES, REMOVE FUEL RESERVOIR TO ELIMINATE ANY PART DAMAGE DUE TO REMOVING THE REAR TRANSMISSION SUPPORT CROSSMEMBER. REFER TO SECTION 24-50, FUEL TANKS AND LINES AND FUEL EVAPORATIVE EMISSION CONTROL SYSTEM.

3. Lower the transmission and remove the transmission jack. Lower the vehicle.

Engine Components

Figs. 11 and 12 are typical and will serve as a reference for the procedures. The numbers and part description shown in the keys are basic part numbers corresponding with the Ford Master Parts Catalog.

Refer to the end of this Section for all specifications and torque values.

Crankcase Ventilation System

Removal

Refer to Figs. 13 and 14.

1. Grasp the positive crankcase ventilation (PCV) regulator valve and pull upward to remove it from the rocker arm cover.
2. Remove the PCV valve from the vent hoses.
3. Remove the air inlet hose from the crankcase filter cap and carburetor air cleaner.

Installation

1. Install the hose on the inlet tube in the intake manifold. Install the PCV valve in the hoses.
2. Insert the PCV valve into the rocker arm cover mounting grommet.

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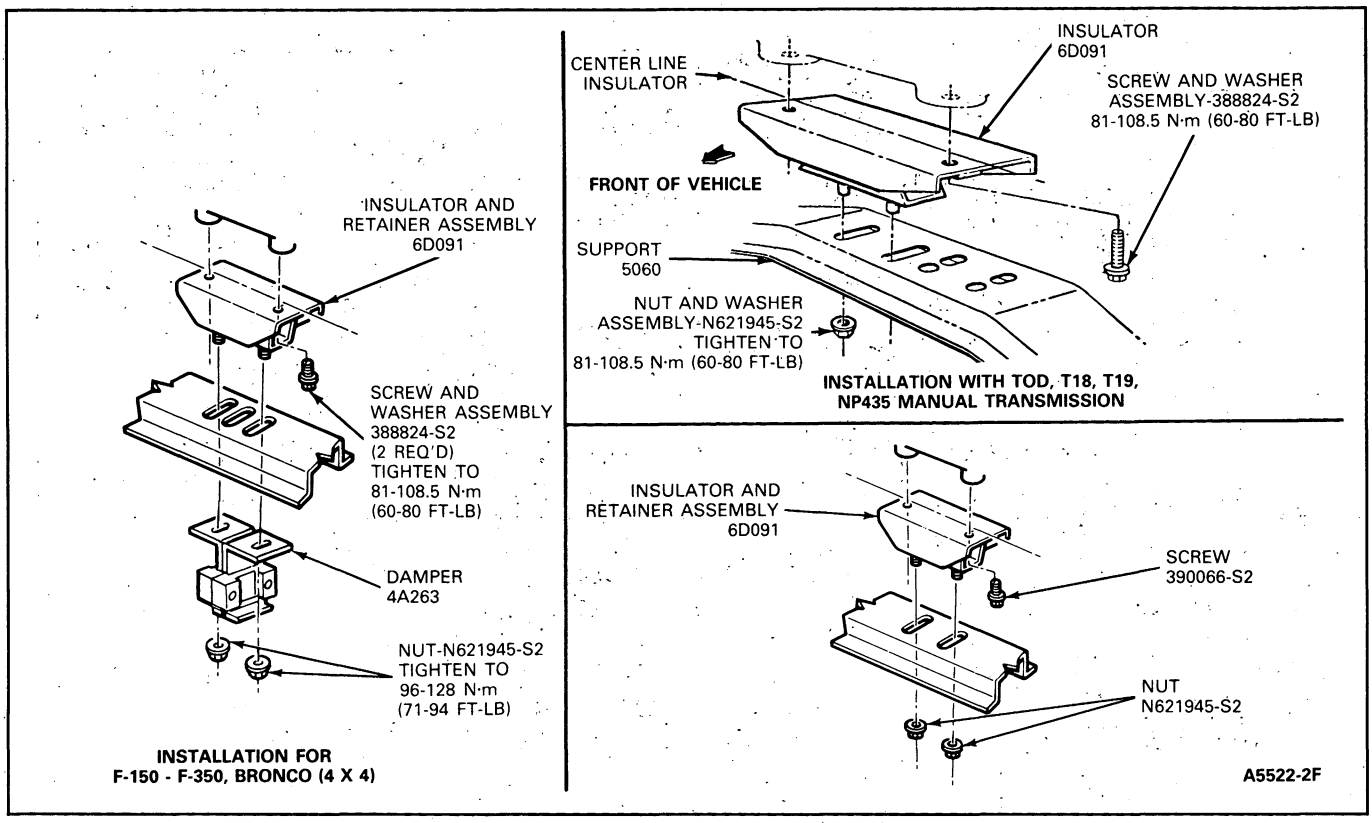


FIG. 10 Engine Rear Support—F-150—F-350 and Bronco

3. Connect the air inlet hose to the crankcase filter cap and air cleaner.
4. Operate the engine and check for leaks.

WARNING: DO NOT OPERATE THE ENGINE WITH THE HOOD OPEN UNTIL THE FAN HAS BEEN FIRST EXAMINED FOR POSSIBLE CRACKS AND BLADE SEPARATION.

Valve Rocker Arm Cover and Rocker Arm

Removal

1. Disconnect the inlet air hose at the crankcase filter cap. Remove the throttle body inlet tubes.
2. Disconnect the accelerator cable at the throttle body. Remove the cable retracting spring. Remove the accelerator cable bracket from the upper intake manifold and position the cable and bracket assembly out of the way.
3. Remove the fuel line from the fuel rail. Do not bend the fuel line.
4. Remove the upper intake and throttle body assembly.
5. Remove the PCV valve from the valve rocker arm cover. Remove the crankcase filter. Remove the cover bolts and remove the valve rocker arm cover. Inspect the rocker arm cover bolts for worn or damaged seals under the bolt heads and replace as necessary.
6. Remove the valve rocker arm bolt, fulcrum seat and rocker arm (Fig. 15).

Installation

1. Apply Multi-Purpose Grease D0AZ-19584-AA or equivalent to the top of the valve stem.
2. Apply Multi-Purpose Grease D0AZ-19584-AA or equivalent to the rocker arm fulcrum seat and the fulcrum seat socket in the rocker arm. Install the valve rocker arm, fulcrum seat and rocker arm bolt. Adjust the valve clearance following the procedure under Valve Clearance Adjustment.
3. Clean the valve rocker arm cover and the cylinder head gasket surface. Place the new gasket on cylinder head making sure that the tabs of the gasket face down towards the head. No sealer or adhesive is necessary.
4. Install the cover on the cylinder head. Make sure the gasket seats evenly all around the head. Partially tighten the cover bolts in sequence, starting at the middle bolts. Then tighten the bolts to 5-9 N·m (4-7 ft-lb) in the same sequence.
5. Install the PCV valve in the rocker arm cover. Install the accelerator cable bracket on the upper intake manifold and connect the cable to the throttle body.
6. Install the upper intake and throttle body assembly.
7. Install the fuel line at the fuel rail.
8. Connect the inlet air hose to the crankcase filter cap.
9. Install throttle body inlet tubes.

Valve Spring, Retainer and Stem Seal

Broken valve springs or worn or damaged valve stem seals and retainers may be replaced without removing the cylinder head providing damage to the valve or valve seat has not occurred.

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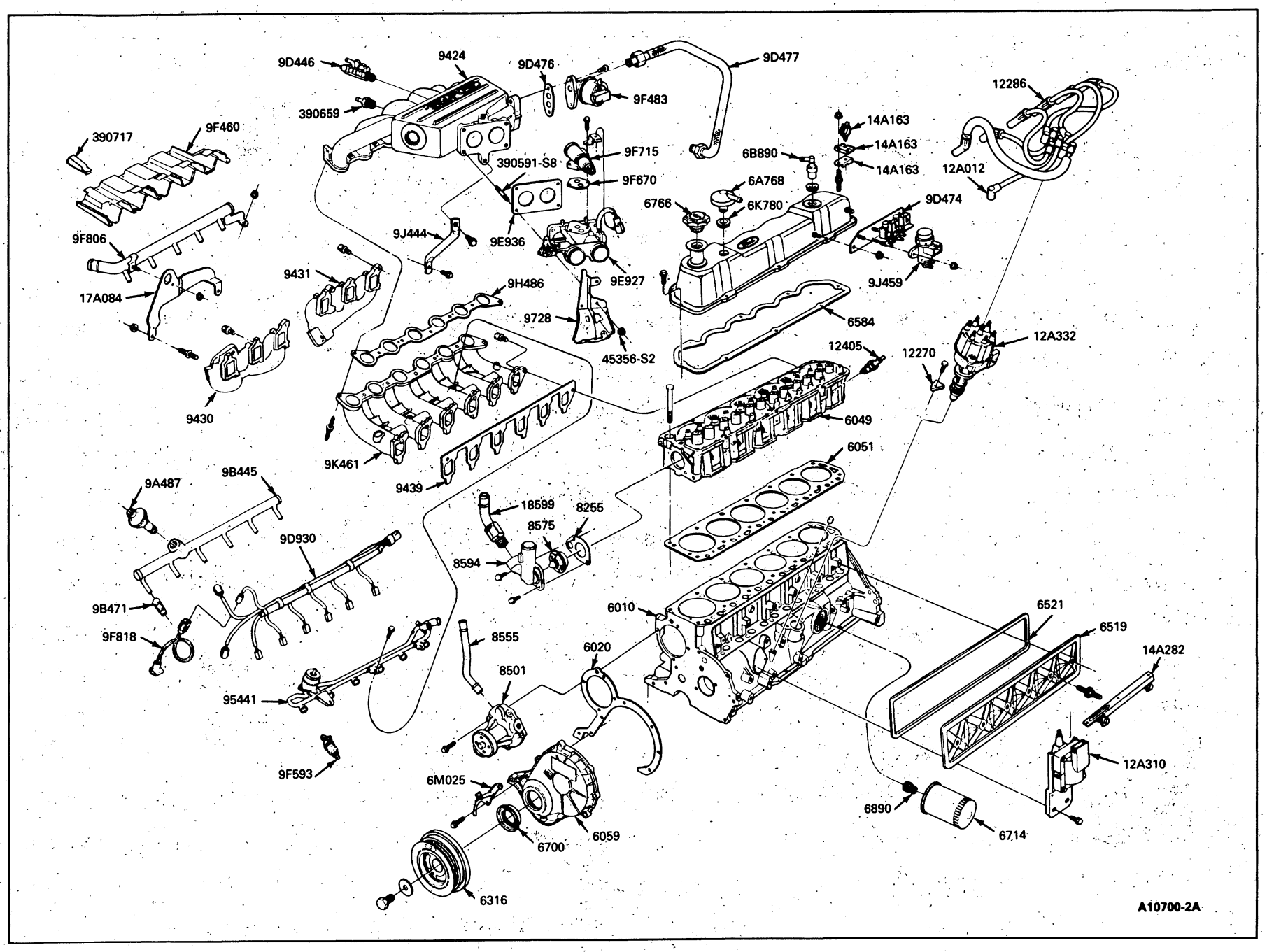


FIG. 11 External Exploded View—4.9L (300 CID) I-6 Engine

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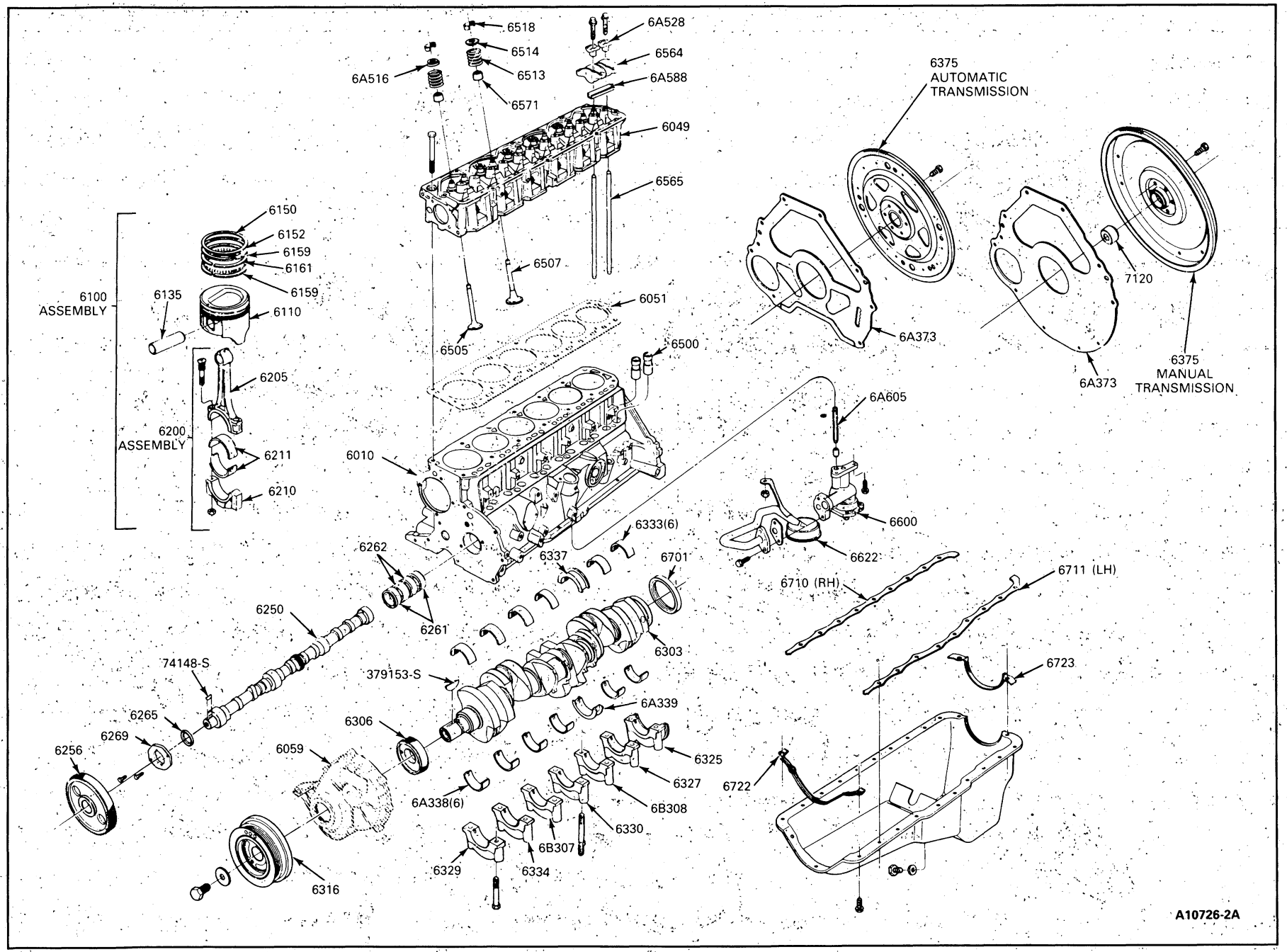


FIG. 12 Internal Exploded View—4.9L EFI (300 CID) I-6 Engine

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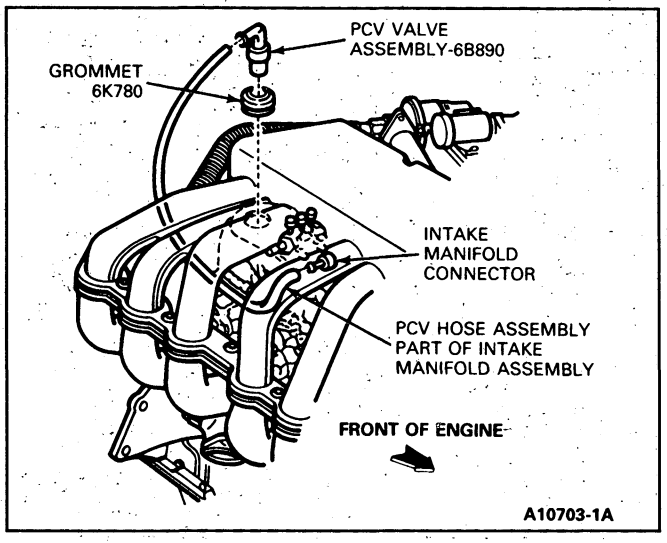


FIG. 13 Typical Closed-Type Crankcase Ventilation System

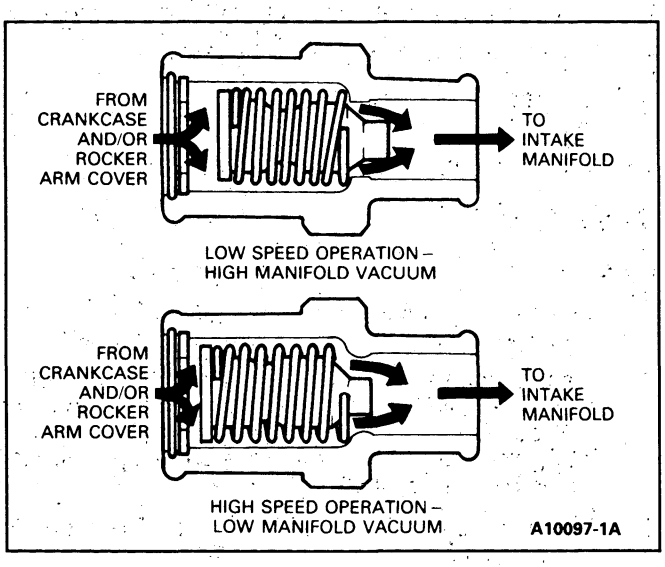


FIG. 14 PCV Valve

Removal

1. Disconnect the inlet air hose at the crankcase filter cap. Remove the throttle body inlet tubes.
2. Disconnect the accelerator cable at the throttle body. Remove the cable retracting spring. Remove the accelerator cable bracket from the upper intake manifold and position the cable and bracket assembly out of the way.
3. Remove the fuel line from the fuel rail. Do not bend the fuel line.
4. Remove the upper intake and throttle body assembly.
5. Remove the PCV valve from the valve rocker arm cover and remove the valve rocker arm cover. Remove the applicable spark plug.
6. Crank the engine until the applicable piston is on TDC at the end of the compression stroke.
7. Install a Valve Holdup Air Adapter TOOL-6513-ABA or equivalent in the spark plug hole (Fig. 16) and connect the air line.

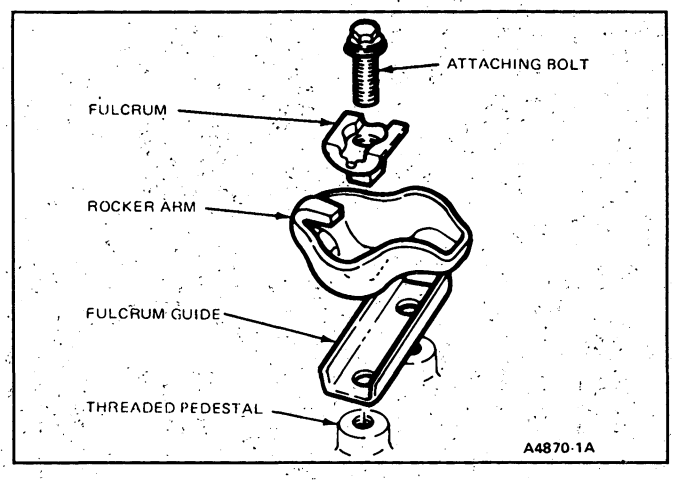


FIG. 15 Valve Rocker Arm Assembly

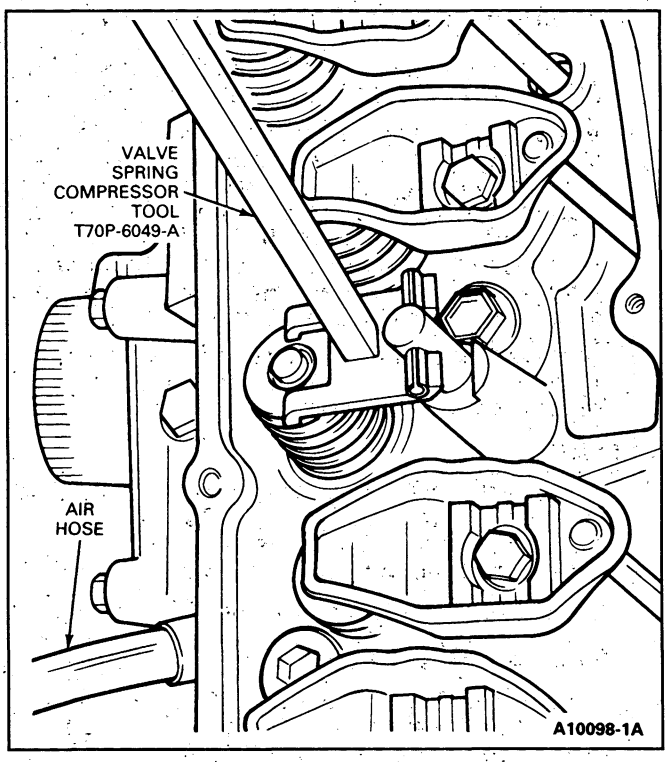


FIG. 16 Compressing Valve Spring—In-Chassis

8. Remove the applicable valve rocker arm bolt, fulcrum seat, valve rocker arm and push rod. Place a block of wood on top edge of valve spring cap and tap moderately with a hammer to unlock valve keys. Install the bolt and position the Valve Spring Compressor T70P-6049-A or equivalent as shown in Fig. 16. Compress the valve spring and remove the retainer locks, spring retainer and valve spring. Remove and discard the valve stem seal (Fig. 17).

   If air pressure fails to hold the valve in the closed position during this operation, it can be presumed that the valve is not seating or is damaged. If this condition occurs, remove the cylinder head for further inspection.

9. If air pressure has forced the piston to the bottom of the cylinder, any removal of air pressure will allow the valve to fall into the cylinder. A rubber band, tape or string wrapped around the end of the

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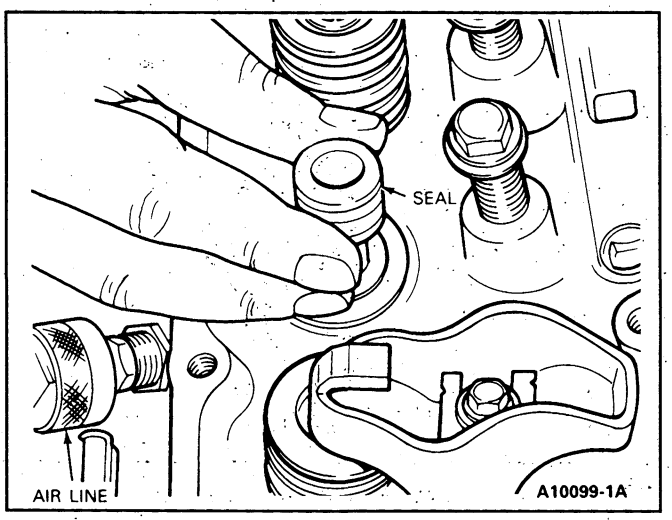


FIG. 17 Removing or Installing Valve Stem Seal

valve stem will prevent this condition and will still allow enough travel to check the valve for binds.

10. Inspect the valve stem for damage. Rotate the valve and check the valve stem tip for eccentric movement during rotation. Move the valve up and down through normal travel in the valve guide and check the stem for binds. **If the valve has been damaged, it will be necessary to remove the cylinder head for repairs. Refer to Section 21-01, General Gasoline Engine Service.**
11. If the condition of the valve proved satisfactory, hold the valve in the closed position and apply air pressure within the cylinder.

Installation

1. Oil the valve stem with heavy engine oil and install a new valve stem seal (Fig. 17). Place the spring in position over the valve. **Ensure the closed coil end is next to the cylinder head.**

   Install the valve spring retainer. Compress the valve spring and install the valve spring retainer locks. Remove the compressor tool and bolt.
2. Apply Multi-Purpose Grease D0AZ-19584-AA or equivalent to both ends of the push rod. Install the push rod. Apply Polyethylene Grease D0AZ-19584-A or equivalent to the top of the valve stem.
3. Apply Multi-Purpose Grease D0AZ-19584-AA or equivalent to the fulcrum seat and socket. Install the valve rocker arm, fulcrum seat, fulcrum guide and bolt. Check the valve clearance following the procedure under Valve Clearance.
4. Turn off the air and remove the air line and adapter. Install the spark plug and connect the spark plug wire.
5. Clean the valve rocker arm cover and cylinder head gasket surface. Install the new gasket on the cover and position the cover on the cylinder head, making sure that the gasket seats evenly around the cylinder head. Install the cover bolts and tighten them in sequence (starting in the center) to 5-9 N·m (4-7 ft-lb).
6. Install the PCV valve in the rocker arm cover. Install the accelerator cable bracket on the upper intake manifold and connect the cable to the throttle body.

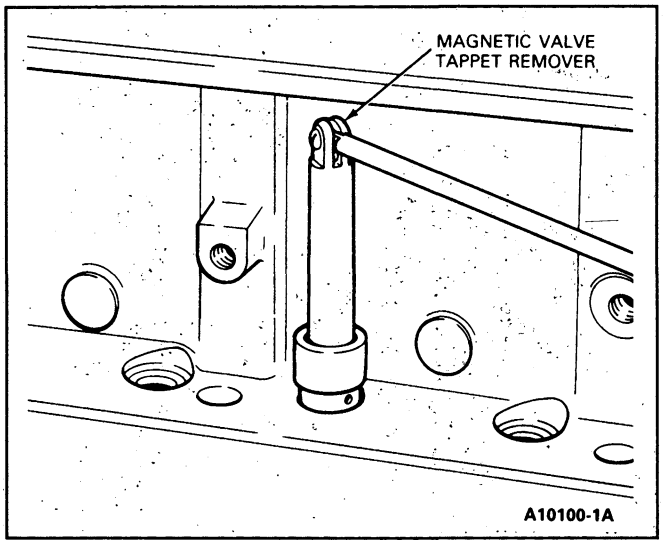


FIG. 18 Removing or Installing Valve Tappet

7. Install the upper intake and throttle body assembly.
8. Install the fuel line at the fuel rail.
9. Connect the inlet air hose to the crankcase filter cap.
10. Install throttle body inlet tubes.

Valve Tappet

Removal

1. Disconnect the inlet air hose at the crankcase filter cap. Remove the throttle body inlet tubes.
2. Disconnect the accelerator cable at the throttle body. Remove the cable retracting spring. Remove the accelerator cable bracket from the upper intake manifold and position the cable and bracket assembly out of the way.
3. Remove the fuel line from the fuel rail. Do not bend the fuel line.
4. Remove the upper intake and throttle body assembly.
5. Remove the coil bracket attaching bolt or "E" core assembly attaching nuts and position the coil out of the way.
6. Remove the valve rocker arm cover.
7. Disconnect the spark plug wires at the spark plugs using Spark Plug Wire Remover T74P-6666-A or equivalent. Remove secondary high tension wire from the coil. Remove the distributor cap and spark plug wire assembly.
8. Remove the valve push rod cover.
9. Loosen the rocker arm bolts until the rocker arm(s) can be disengaged from the push rod(s). Remove the push rod(s). Remove the valve tappet(s) with the tool shown in Fig. 18. If more than one push rod and valve tappet is removed, do so in sequence and place the parts in a rack so they can be installed in their original locations.

   Refer to Section 21-01, General Gasoline Engine Service for the cleaning, inspection and testing procedures.

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Installation

1. Clean the external surfaces of the valve tappets, rocker arm cover, push rod cover, cylinder head and block gasket surfaces.
2. Apply Multi-Purpose Grease D0AZ-19584-AA or equivalent to the cam lobe contact surface of the valve tappet(s). Coat the rest of the valve tappet(s) with engine oil. Install the valve tappets with the tool shown in Fig. 17.
3. Apply Multi-Purpose Grease D0AZ-19584-AA or equivalent to both ends of the push rod(s). Install the push rod(s) in sequence. Engage the rocker arm(s) with push rod(s) and tighten the rocker arm bolts sufficiently to hold the push rod(s) in place. **Ensure each push rod is properly seated in the valve tappet socket.**
4. Adjust the valve clearance as outlined.
5. Coat one side of a new push rod cover gasket with Perfect Seal Sealing Compound B5A-19554-A or equivalent oil resistant sealer, and position to the push rod cover. Install the push rod cover. Tighten the cover screws in sequence to 2.8-4.0 N·m (25-35 in-lb). Clean the rocker arm cover. Place the new gasket in the rocker arm cover. Install the rocker arm cover and tighten the bolts to 7.9-11.9 N·m (70-105 in-lb). Install the PCV valve in the rocker arm cover.
6. Position the coil assembly on the cylinder head and install the attaching bolt or nuts.
7. Install the distributor cap and spark plug wire assembly. Connect the spark plug wires and coil secondary high tension wire.
8. Install the accelerator cable bracket on the upper intake manifold and connect the cable to the throttle body.
9. Install the fuel line at the fuel rail.
10. Install the throttle body inlet tubes.

Cylinder Head

Removal

If the cylinder head is to be replaced, follow the procedures under Cylinder Head Disassembly and Assembly. Transfer all valves, springs, spark plugs, etc., to the new cylinder head. Clean and inspect all parts, reface the valves and check valve guide clearances before assembling the used parts to the new cylinder head. Refer to Section 21-01, General Gasoline Engine Service.

1. Drain the cooling system and the crankcase. Remove the hood. Remove the throttle body inlet tubes. Remove air conditioner compressor and condenser. Refer to applicable Section in Group 36 in the Body/Chassis/Electrical Manual.
2. Disconnect the battery ground cable. Disconnect the heater hose from the water pump and coolant outlet housing. Disconnect the flexible fuel line from the fuel pump.
3. Remove the radiator. Refer to Section 27-04, Radiators.
4. Remove the cooling fan, viscous fan drive, water pump pulley and fan drive belt (Fig. 7).
5. Disconnect the accelerator cable at the throttle body. Remove the cable retracting spring.

   On a vehicle with power brakes, disconnect the vacuum line at the intake manifold.

   On a vehicle with an automatic transmission, disconnect the transmission kickdown cable at the throttle body.
6. Disconnect the exhaust manifold from the muffler inlet pipe. Disconnect the body ground strap and the battery ground cable at the engine.
7. Disconnect the Electronic Engine Control (EEC) harness from all sensors (if so equipped).
8. Disconnect the engine wiring harness at the ignition coil, coolant temperature sending unit and oil pressure sending unit. Position the harness out of the way.
9. Remove the alternator mounting bolts and position the alternator out of the way, leaving the wires attached.

   Remove power steering pump from the mounting brackets and position it right side up and to one side, leaving the lines attached. If equipped with an air compressor, bleed the air system and disconnect the two air pressure lines at the compressor.
10. Remove the coil bracket attaching bolts and position the coil out of the way.
11. Remove the valve rocker arm cover. Loosen the rocker arm bolts so that the rocker arms can be rotated to one side.
12. Remove the valve push rods in sequence and identify them so that they can be installed in their original position.
13. Disconnect the spark plug wires at the spark plugs using Spark Plug Wire Remover T74P-6666-A or equivalent (Fig. 19).
14. Remove the cylinder head bolts. Install the cylinder head lifting eyes using Engine Lifting Bracket T70P-6000 or equivalent, in the locations shown in Fig. 20. Position a floor crane and attach the hoist and lifting sling to the lifting eyes using Rotunda Engine Sling 014-00036 Sling and Rotunda Floor Crane 014-00133 or equivalents. Lift the cylinder head and intake and exhaust manifolds assemblies off the engine. **Do not pry between the head and block as the gasket surfaces may become damaged.**

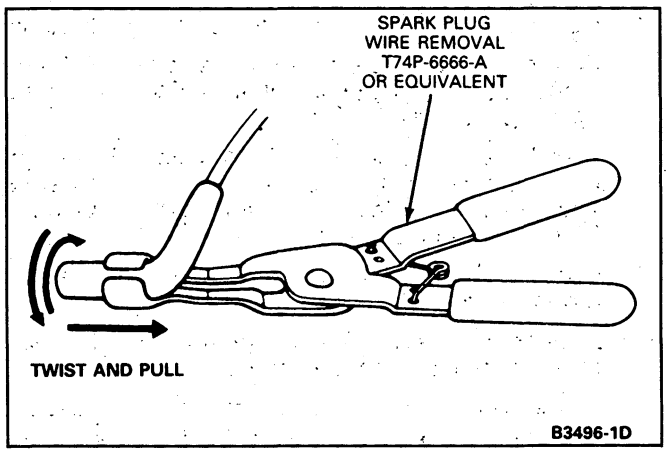


FIG. 19 Removing Wires From Spark Plugs

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Installation

1. Clean the cylinder head and cylinder block gasket surfaces. Clean the exhaust manifold and muffler inlet pipe gasket surfaces.
2. If the cylinder head was removed for a cylinder head gasket replacement, check the flatness of the head and block gasket surfaces. Refer to Section 21-01, General Gasoline Engine Service.
3. Position the gasket over the dowel pins on the cylinder block.
4. Install lifting eyes on the cylinder head in the location shown in Fig. 20 and use a floor crane and lifting sling to lift the cylinder head over the cylinder block. Lower it carefully until it is properly positioned on the block and dowel pins. Remove the hoist and lifting eyes.
5. Coat the threads of the cylinder head bolts with engine oil. Install the bolts.
6. Tighten the bolts in numerical sequence shown in Fig. 20. Bolts are tightened in three steps.
   - 1st step—tighten all bolts to 67-75 N·m (50-55 ft-lb).
   - 2nd step—tighten all bolts to 82-88 N·m (60-65 ft-lb).
   - 3rd step—tighten all bolts to 94-115 N·m (70-85 ft-lb).

   When cylinder head bolts have been tightened it is not necessary to re-tighten the bolts after extended operation.
7. Apply Multi-Purpose Grease D0AZ-19584-AA or equivalent to both ends of the push rods. Install the push rods in their original bores, positioning the lower end of the rods in the valve tappet sockets.
8. Apply Multi-Purpose Grease D0AZ-19584-AA or equivalent to the rocker arm fulcrum seat and the fulcrum seat socket in the rocker arm. Position the rocker arms and tighten the rocker arm bolt just enough to hold the push rods in position. Check the valve clearance as outlined.
9. Clean the valve rocker arm cover. Place the new gasket and position the cover, making sure that the gasket seats evenly around the cylinder head. Install the cover bolts and tighten in sequence (starting in the center) to 7.9-11.9 N·m (70-105 in-lb).
10. Connect the spark plug wires to the spark plugs.
11. Connect the crankcase vent hose to the inlet tube in the intake manifold. Install the PCV valve in the valve rocker arm cover.
12. Install the exhaust manifold-to-muffler inlet pipe lockwashers and nuts. Tighten the nuts to specification. Refer to Section 26-01, General Exhaust Systems Service.
13. Connect the engine ground strap and the battery ground cable.
14. Connect Electronic Engine Control (EEC) harness to all sensors, if so equipped.
15. On a vehicle with an automatic transmission, connect the kickdown cable to the throttle body.

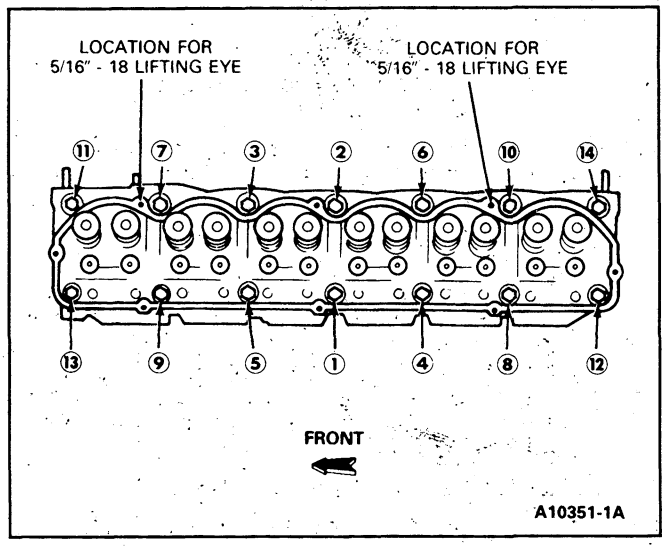


FIG. 20 Cylinder Head Bolts Tightening Sequence

Connect the accelerator linkage to the carburetor and install the retracting spring.

On a vehicle with power brakes, connect the brake vacuum line to the intake manifold.

16. Connect the coil primary wire, oil pressure and coolant temperature sending unit wires, flexible fuel line, heater hoses and the battery positive cable.
17. Install the alternator on the mounting bracket.

    On a vehicle with power steering, install the power steering pump on the mounting brackets.
18. Install the water pump pulley, viscous fan drive, RH threads on fan clutch, cooling fan and drive belt. Tighten the fan bolts to 16.2-24.4 N·m (12-18 ft-lb) (Fig. 7).

    Tighten the alternator, power steering pump and air compressor mounting bolts to specification. Refer to Section 27-06, Accessory Drive Belt Service.
19. Install the radiator. Connect the radiator lower hose to the water pump and the radiator upper hose to the coolant outlet housing. Connect the air compressor lines. If removed, install air conditioner compressor and condenser.

    On a vehicle with an automatic transmission, connect the oil cooler lines.
20. If applicable, install and adjust the hood.
21. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service. Fill the crankcase. Operate the engine at fast idle and check all hose connections and gaskets for leaks.
22. Perform EEC Quick Test to check the function of the EEC system, if so equipped. Refer to Engine/ Emissions Diagnosis* manual.
23. On a vehicle with standard transmission, adjust the clutch pedal free travel. Refer to Section 16-03, Mechanical Clutch Linkage.

    On a vehicle with an automatic transmission, adjust the transmission control linkage. Refer to Section 17-02, Shift Control Linkage. Check the

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fluid level and add as required to bring it to the proper level on the oil indicator.

24. Install the throttle body intake tubes.

Manifolds

Removal

1. Disconnect the inlet air hose at the crankcase filter cap. Remove the throttle body inlet hoses.
2. Disconnect the accelerator cable at the throttle body. Remove the cable retracting spring. Remove the accelerator cable bracket from the upper intake manifold and position the cable and bracket assembly out of the way.
3. Remove the fuel line from the fuel rail. Do not bend the fuel line.
4. Remove the upper intake and throttle body assembly.
5. Disconnect all the vacuum lines. Label the lines so they are re-installed properly.
6. Disconnect the inlet pipe from the exhaust manifolds.
7. Disconnect the power brake vacuum line (if so equipped).
8. Remove the bolts attaching the manifolds to the cylinder head. Lift the manifolds from the engine. Remove and discard the gaskets.

Installation

1. Clean the mating surfaces of the cylinder head and manifolds.
2. If one of the manifolds is to be replaced, remove the tube fittings from the discarded manifolds and install them in the new manifold as required. Also install new studs in the new manifold.
3. Install a new intake manifold gasket.

NOTE: Combination intake/exhaust gasket is not to be used on a new exhaust manifold. Gasketing of the exhaust manifold is only recommended when the original exhaust manifold is reinstalled, in order to prevent leakage.

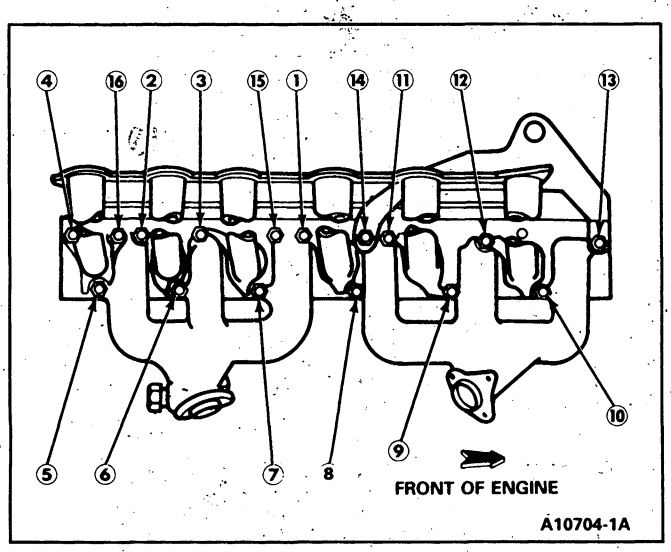


FIG. 21 Intake and Exhaust Manifold Bolts Tightening Sequence

4. Coat the mating surfaces lightly with Steering Gear Grease C3AZ-19578-A or equivalent graphite grease. Place the manifold assemblies in position against the cylinder head. **Make sure that the gasket has not become dislodged. Install the attaching washers, bolts and nuts.** Tighten the bolts and nuts on intake manifold to 30-43 N·m (22-32 ft-lb) and on exhaust manifold to 30-43 N·m (22-32 ft-lb) in the sequence shown in Fig. 21.
5. Connect the inlet pipe to the exhaust manifold. Tighten the nuts to specifications.
6. Connect the crankcase vent hose to the intake manifold and position the hose clamp.
7. Install the upper intake and throttle body assembly using new gaskets.
8. Install the exhaust manifold-to-muffler inlet pipe lockwashers and nuts. Tighten the nuts to specification. Refer to Section 26-01, General Exhaust Systems Service.
9. Connect the engine ground strap and the battery ground cable.
10. Connect Electronic Engine Control (EEC) harness to all sensors, if so equipped.
11. On a vehicle with an automatic transmission, connect the kickdown cable to the throttle body.

    Connect the accelerator linkage to the throttle body and install the retracting spring.

    On a vehicle with power brakes, connect the brake vacuum line to the intake manifold.
12. Connect the coil primary wire, oil pressure and coolant temperature sending unit wires, flexible fuel line, heater hoses and the battery positive cable.
13. Install the alternator on the mounting bracket.

    Install the power steering pump on the mounting brackets.
14. Install the water pump pulley, viscous fan drive, RH threads on fan clutch, cooling fan and drive belt. Tighten the fan bolts to 16.2-24.4 N·m (12-18 ft-lb) (Fig. 7).

    Tighten the alternator, power steering pump and air compressor mounting bolts to specification. Refer to Section 27-06, Accessory Drive Belt Service.
15. Install the radiator. Connect the radiator lower hose to the water pump and the radiator upper hose to the coolant outlet housing. Connect the air compressor lines. If removed, install air conditioner compressor and condenser.

    On a vehicle with an automatic transmission, connect the oil cooler lines.
16. If applicable, install and adjust the hood.
17. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service. Fill the crankcase. Operate the engine at fast idle and check all hose connections and gaskets for leaks.
18. Perform EEC Quick Test to check the function of the EEC system, if so equipped. Refer to Engine/ Emissions Diagnosis* manual.

*Can be purchased as a separate item.

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19. On a vehicle with manual transmission, adjust the clutch pedal free travel. Refer to Section 16-03, Mechanical Clutch Linkage.

    On a vehicle with an automatic transmission, adjust the transmission control linkage. Refer to Section 17-02, Shift Control Linkage. Check the fluid level and add as required to bring it to the proper level on the oil indicator.

20. Install the throttle body intake tubes.

Water Pump

Removal

1. Drain the cooling system. Loosen the alternator adjusting arm bolt and remove the alternator drive belt. On a vehicle with an air compressor, remove the compressor belt.
2. Remove the fan, viscous fan drive, RH thread on clutch, and pulley (Fig. 7).
3. Disconnect the heater hose, radiator lower hose and radiator supply line at the water pump.
4. Remove the bolts attaching the water pump to the block. Remove the pump and gasket.

Installation

1. Remove the fittings from the old pump and install them on the new pump. Clean all gasket material from the mounting surfaces of the water pump and cylinder block.
2. Position a new gasket, coated on both sides with sealer, on the water pump.
3. Install the pump body on the block. Install the pump attaching bolts, coated with sealer, and tighten the bolts to 17-24 N·m (12-18 ft-lb).
4. Connect the radiator lower hose, radiator supply line and heater hose. Install the pulley and fan. Install the alternator belt and adjust the belt tension. On a vehicle with an air compressor, install the air compressor belt and adjust the belt tension to specifications. Refer to Section 27-06, Accessory Drive Belt Service. Fill and bleed the cooling system. Operate the engine and check for leaks.

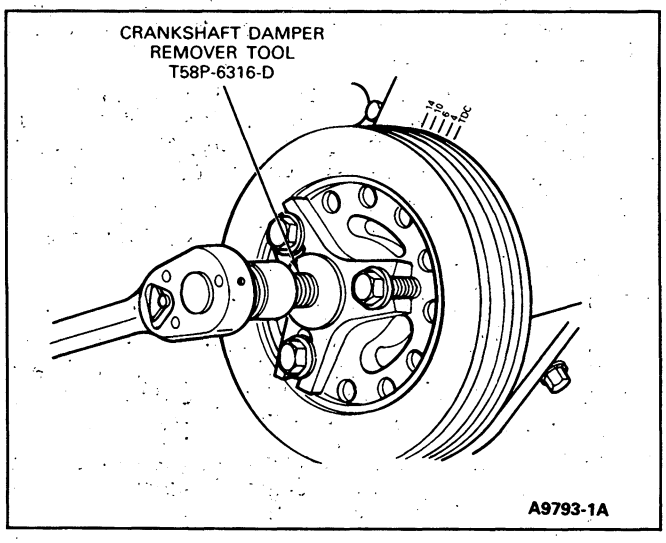


FIG. 22 Removing Crankshaft Damper

Cylinder Front Cover

Removal

1. Drain the cooling system.
2. Remove the shroud and radiator.
3. Remove the drive belt, power steering bracket bolts and swing aside. Remove the fan, drive belts and pulleys (Fig. 7).
4. Remove the screw and washer from the end of the crankshaft and remove the damper using Crankshaft Damper Remover T58P-6316-D or equivalent (Fig. 22).
5. Remove the front oil pan and front cover attaching screws. Loosen the first six bolts on each side of the pan. Lightly push pan down so it does not exert any upward force on the front cover, which may affect front seal alignment.

CAUTION: Avoid foreign material from entering the crankcase during service work or the crankcase oil will have to be changed.

6. Remove the cylinder front cover and discard the gasket. Replace crankshaft oil seal whenever the cylinder front cover is removed.

Installation

1. Clean front cover and block gasket surfaces. Also, clean any oil on oil pan gasket as it will be used over.
2. Coat front cover gasket surfaces of the block and cover with Perfect Seal Sealing Compound B5A-19554-A or equivalent oil resistant sealer. Position a new front cover gasket on the block.
3. Apply Silicone Rubber D6AZ-19562-AA or BA or equivalent to the block/pan junction (Fig. 23) and a small bead on oil pan gasket sealing surface of front cover. This provides an additional seal between front cover and the used oil pan gasket.

   NOTE: When applying RTV sealant always use the bead size specified and join the components within 15 minutes of application. After this amount of time the sealant begins to "set-up" and its sealing effectiveness may be reduced.

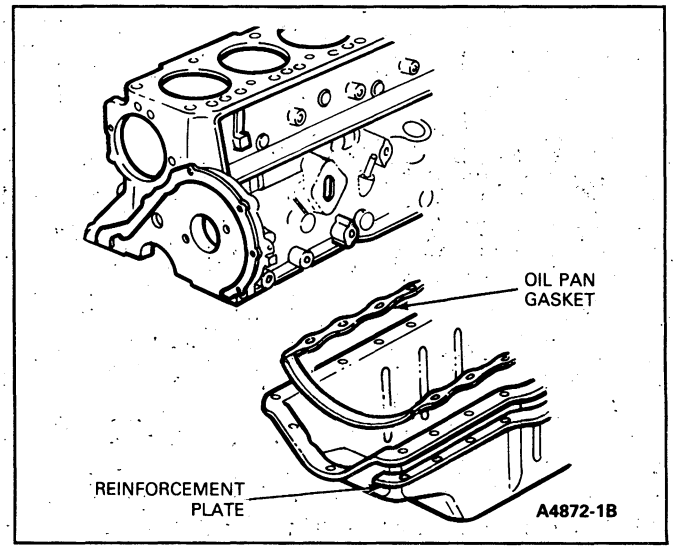


FIG. 23 Oil Pan Gaskets and Front Seal Installed (Typical)

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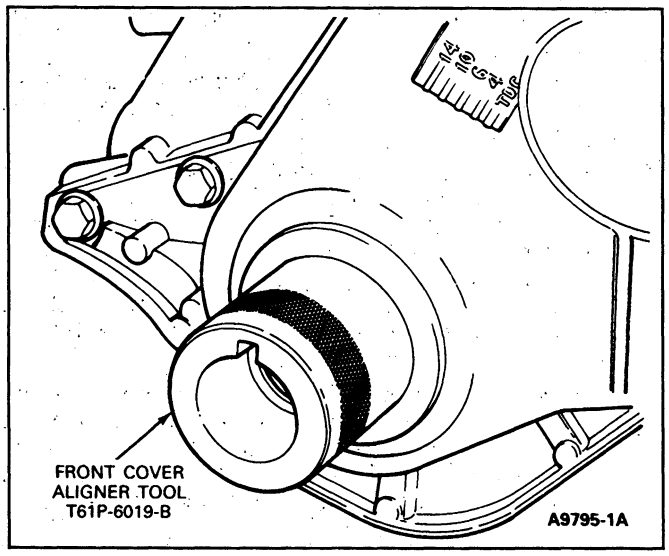


FIG. 24 Aligning Cylinder Front Cover

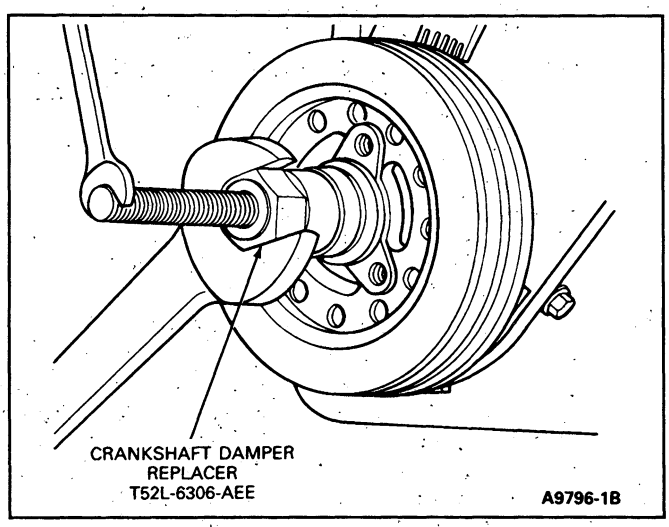


FIG. 25 Installing Damper

4. Position the front cover assembly over the end of the crankshaft and against the cylinder block. Start the cover and pan attaching screws. Slide the Front Cover Aligner T61P-6019-B or equivalent over the crank stub and into the seal bore of the cover (Fig. 24). Tighten attaching oil pan screws to 14-20 N·m (10-15 ft-lb) and front cover screws to 17-24 N·m (12-18 ft-lb).

NOTE: Tighten front cover screws first to obtain proper cover alignment.

5. Lubricate the crank stub, damper hub I.D. and the seal rubbing surface with clean engine oil or 50 weight oil only. DO NOT use grease on seal. Apply a 6mm (1/4-inch) bead of silicon rubber to inside of keyway of damper hub. Align the damper keyway with the key on the crankshaft and install the damper using Crankshaft Sprocket and Damper Replacer T52L-6306-AEE or equivalent (Fig. 25).
6. Install the washer and capscrew. Tighten to 177-203 N·m (130-150 ft-lb).
7. Install the pulley(s), drive belt(s), spacer (if used) and fan (Fig. 7). Adjust all drivebelt tensions to specification. Refer to Section 27-06, Accessory Drive Belt Service.

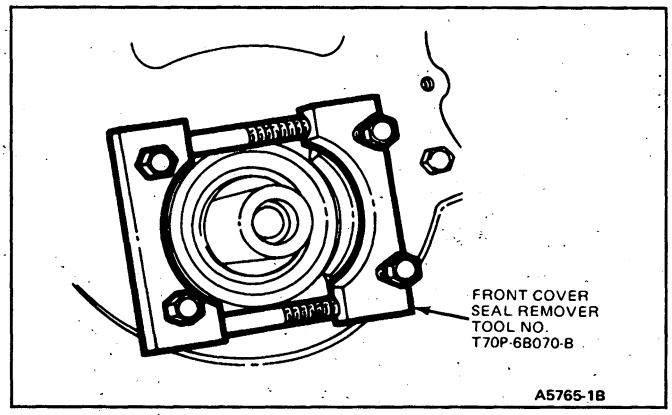


FIG. 26 Removing Front Crankshaft Seal

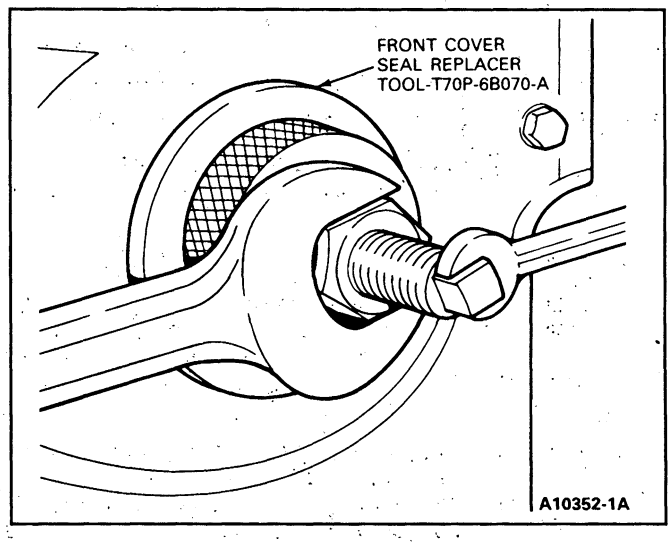


FIG. 27 Installation of Front Cover Seal

8. Install the shroud, radiator, and hoses.
9. Fill and bleed the cooling system. Use the specified antifreeze mix. Refer to Section 27-02, Cooling System Service. If foreign material has not entered the crankcase during the service work, it is not necessary to change the engine oil.
10. Operate the engine at fast idle and check for coolant and oil leaks.

Front Oil Seal

Removal

1. Remove the bolts attaching the fan shroud to the radiator.
2. Remove the fan and spacer bolts from the water pump shaft. Remove the fan, spacer and shroud.
3. Loosen the alternator, power steering, Thermactor and air conditioner drive belts.
4. Remove the crankshaft pulley from the vibration damper. Remove the damper attaching screw and washer. Install the puller on the crankshaft vibration damper and remove the vibration damper.
5. Place the Front Cover Seal Remover T70P-6B070-B or equivalent onto the front cover plate over the front seal (Fig. 26). Tighten the two through bolts to force the seal puller under the seal flange.

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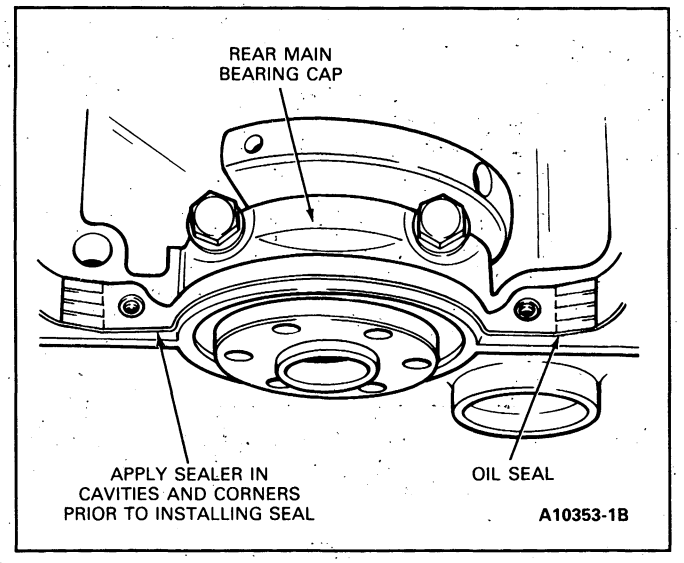


FIG. 28 Installing Oil Pan Seal At Rear Of Engine

6. Alternately tighten the four puller bolts one half turn at a time (Fig. 26). Pull the oil seal from the front cover.

Installation

1. Coat a new front cover plate oil seal with CLEAN engine oil or 50 weight oil only. Place the sleeve and seal onto the end of the crankshaft and push it toward the engine until the seal starts into the front cover.
2. Place the installation screw, washer, and nut onto the end of the crankshaft. Thread the screw into the crankshaft. Tighten the nut against the washer and installation sleeve to force the seal into the front cover plate. Remove the installation tool from the crankshaft.
3. Apply CLEAN engine oil or 50 weight oil only. DO NOT use grease to the oil seal rubbing surface of the vibration damper inner hub to prevent damage to the seal. Apply CLEAN engine oil or 50 weight oil only. DO NOT use grease to the front of the crankshaft for damper installation.

Apply a 6mm (1/4-inch) bead of silicone rubber to inside of keyway of damper hub. Install in five minutes.

4. Line up the crankshaft vibration damper keyway with the key on the crankshaft. Install the vibration damper on crankshaft. Install the capscrew and washer. Tighten the screw to 95-122 N·m (70-90 ft-lb). Install the crankshaft pulley.
5. Install the alternator, power steering pump, Thermactor and air conditioner belts.
6. Position the fan shroud over the water pump pulley. Install the fan and spacer. Install the fan shroud attaching screws.
7. Adjust the drive belts to specification. Refer to Section 27-06, Accessory Drive Belt Service.

Oil Pan

F-150—F-350 and Bronco

Removal

1. Drain the crankcase and the cooling system.
2. Remove the upper intake and throttle body assembly.
3. Raise the vehicle on a hoist. Disconnect the starter cable at the starter and remove the attaching bolts and starter.
4. Remove the engine front support insulator-to-support bracket nuts and washers on both supports. Raise the front of the engine with a transmission jack and wood block and place 25.4mm (1-inch) thick wood blocks between the front support insulators and support brackets. Lower the engine and remove the transmission jack.
5. Remove the oil pan attaching bolts and lower the pan to the crossmember. Remove the two oil pump bolts and the one oil pump inlet tube nut, and drop the assembly in the oil pan. Remove the oil pan. Remove the oil pan gasket. Remove the inlet tube and screen from the oil pan.

Installation

1. Clean the gasket surfaces of the oil pump, oil pan and cylinder block. Clean the seal grooves.
2. Apply a pressure sensitive silicone based adhesive (such as G.E., Dow, Loctite or equivalent) to block rails and front cover oil pan.
3. Apply a bead of RTV Silicone Rubber D6AZ-19562 AA or BA (ESE-M4G195-A) or equivalent (2 places) to parting line between front cover and block. Also (2 places) to tapered ends of rear seal portion of gasket. Immediately install gasket block to facilitate pan installation.
4. Clean the inlet tube and screen assembly and place it in the oil pan.
5. Position the oil pan under the engine. Install the inlet tube and screen assembly on the oil pump with a new gasket. Tighten the two screws to 14-20 N·m (10-15 ft-lb) and one nut to 30-43 N·m (22-32 ft-lb). Position the oil pan against the cylinder block and install stiffener (reinforcement) plates and the attaching bolts (Fig. 29). Tighten the bolts in sequence to 14-20 (10-15 ft-lb).
6. Raise the engine with a transmission jack and remove the wood blocks from the engine front supports. Lower the engine until the front support insulators are positioned on the support brackets. Install the washers and nuts on the insulator studs and tighten the nuts to 73-100 N·m (54-74 ft-lb).
7. Install the starter and connect the starter cable.
8. Lower the vehicle. Install the radiator. Refer to Section 27-04, Radiators.
9. Install the upper intake and throttle body assembly.
10. Fill the crankcase and cooling system. Refer to Section 27-02, Cooling System Service.
11. Start the engine and check for coolant and oil leaks.

E-150—E-350

Removal

1. Remove engine cover.
2. Remove air cleaner. Disconnect the air inlet tubes from the throttle body.
3. If vehicle is equipped with air conditioning, discharge the refrigerant from the system and

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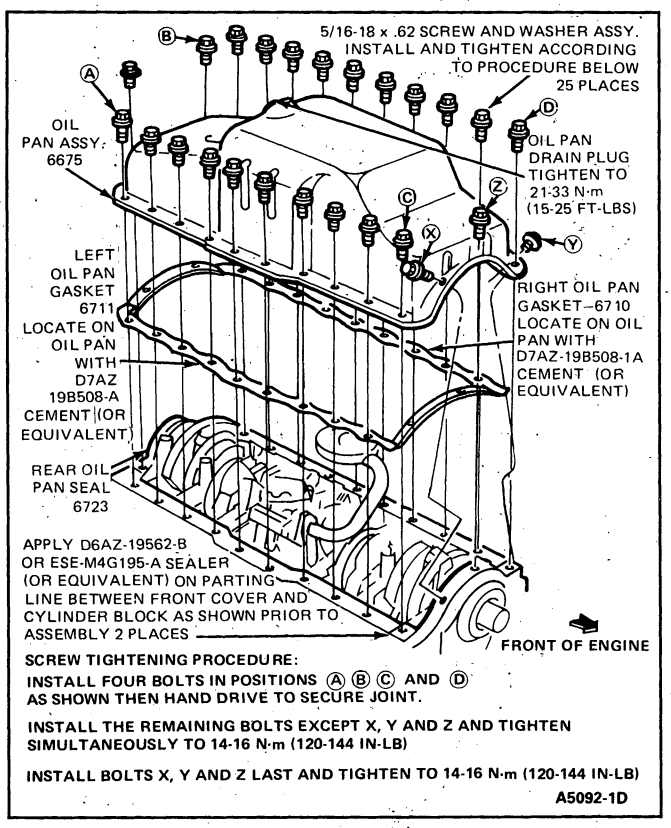


FIG. 29 Oil Pan Installation

remove compressor. Refer to Section 36-30, Air Conditioning General Service in the Body/Chassis/Electrical Manual.

4. Remove the EGR valve.
5. Remove the upper intake and throttle body assembly.
6. If vehicle is an E-250HD or E-350, disconnect Thermactor check valve inlet hose and remove check valve.
7. Remove upper radiator hose.
8. Unbolt fan shroud and remove, or position the shroud on the fan.
9. If vehicle has automatic transmission, remove transmission fill tube.
10. Remove exhaust inlet pipe-to-manifold nuts.
11. Raise vehicle on hoist and disconnect fuel pump inlet hose. Plug the line.
12. Remove front engine support nuts.
13. Remove power steering return line clip located in front of the No. 1 crossmember.
14. Disconnect lower radiator hose and transmission cooler lines.
15. Remove the starter.
16. Raise the engine and place a 76mm (3-inch) block under the engine mounts. Remove the oil pan dipstick tube from the oil pan.
17. Remove oil pan bolts and the pickup tube and screen from the oil pump. Remove the pan.
18. Clean oil pan, tube and screen assembly, seal groove and the gasket surfaces of the block and oil pan.

Installation

1. Install the oil pump tube and screen assembly.
2. Apply a pressure sensitive silicone based adhesive (such as G.E., Dow, Loctite or equivalent) to block rails and front cover oil pan.
3. Apply a bead of RTV Silicone Rubber, D6AZ-19562-AA or BA (ESE-M4*G195-A) or equivalent (2 places) to parting line between front cover and block. Also (2 places) to tapered ends of rear seal portion of gasket. Immediately install gasket to block to facilitate pan installation.
4. Install oil pan and stiffener plates. Tighten to 21-33 N·m (15-25 ft-lb).
5. Install the dipstick tube and lower the engine.
6. Install the support nuts.
7. Install the starter and connect the fuel line.
8. Install lower radiator hose and transmission cooler lines.
9. Install the power steering return line clip and position the line.
10. Lower the hoist.
11. Install the upper intake and throttle body assembly.
12. Install the EGR valve and carburetor. Connect the exhaust.
13. Install Thermactor check valve and connect inlet hose (E-250HD or E-350 only).
14. Install fan shroud and upper radiator hose. Replace engine coolant. Refer to Section 27-02, Cooling System Service.
15. Install A/C compressor and charge system. Refer to Section 36-30, Air Conditioning General Service in the Body/Chassis/Electrical Manual.
16. Replace the oil filter and fill the crankcase. Start the engine and check for leaks.
17. Install air cleaner and air inlet tubes. Install engine cover.

Oil Pump

Removal

1. Remove the oil pan following the procedures under Oil Pan Removal.
2. Remove the oil pump attaching bolts (Fig. 30) and oil pump inlet tube nut. Then, remove the pump assembly.

Installation

1. Prime the oil pump by filling the inlet opening with oil and rotate the pump shaft until oil emerges from the outlet opening.
2. Install the oil pump on the cylinder block. Tighten the attaching bolts and nuts to specifications.
3. Install the oil pan following the procedures under Oil Pan Installation.

Camshaft

The camshaft and related parts are shown in Fig. 31.

Removal

1. Drain the cooling system and the crankcase.

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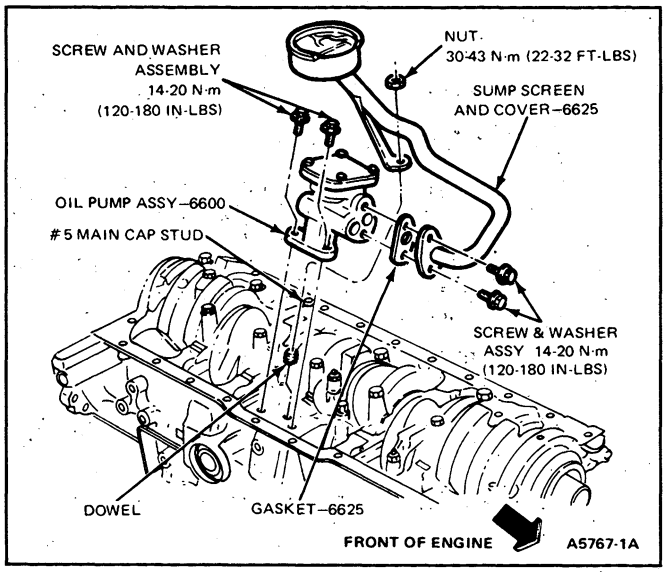


FIG. 30 Oil Pump Installed

2. Remove the shroud and radiator, valve tappets and cylinder front cover, following the procedures given in this Section and Section 27-04, Radiators.
3. Disconnect primary wire at the coil. Remove the distributor following the procedure in Section 23-01, General Ignition Service for breakerless ignition systems.
4. Check the camshaft end play, the timing gear backlash and the timing gear runout. Refer to Section 21-01, General Gasoline Engine Service.
5. Turn the crankshaft to align the timing marks as shown in Fig. 32.
6. Remove the camshaft thrust plate screws (Fig. 34). Remove the camshaft gear using Camshaft Gear Puller T82T-6256-A or equivalent, as shown in Fig. 33. Remove the key, thrust plate and spacer. Remove the camshaft. **Avoid damaging the camshaft bearings lobes during removal.**

Installation

If the camshaft end play, timing gear backlash and/or timing gear runout were excessive, make the necessary corrections before installing the camshaft.

1. Oil the camshaft bearing journals and apply Multi-Purpose Grease D0AZ-19584-AA or equivalent to all the lobes.
2. Assemble key, spacer and thrust plate to camshaft. Align the gear keyway with the key and install the gear on the camshaft using Camshaft Gear Replacing Adapter T65L-6306-A or equivalent as shown in Fig. 35.
3. Install the camshaft, gear and thrust plate as an assembly, making sure that the timing marks are in alignment (Fig. 32). Use care to avoid bearing damage.
4. Tighten the thrust plate attaching screws to 13-16 N·m (9-12 ft-lb).
5. Crank the engine until the timing marks are aligned. **Do not turn the crankshaft again until the distributor is installed.**
6. Clean the cylinder front cover and cylinder block gasket surfaces. Install a new oil seal in the cylinder front cover if necessary. **Clean the crankshaft damper and inspect it. Refer to Section 21-01, General Gasoline Engine Service.** Install the cylinder front cover and damper, valve tappets and radiator, following the installation procedures given in this Section and Section 27-04, Radiators.

   Install the distributor. Refer to Section 23-01, General Ignition Service. With the rotor at No. 1 firing position, align the stator armature tooth exactly with the armature tooth prior to tightening the hold-down clamp.
7. Fill the crankcase and cooling system. Refer to Section 27-02, Cooling System Service.
8. Start the engine and check for oil, coolant and fuel leaks. Adjust the ignition timing.

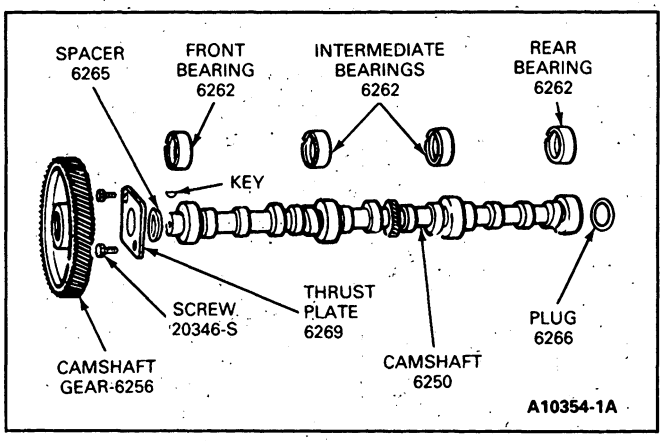


FIG. 31 Camshaft Assembly

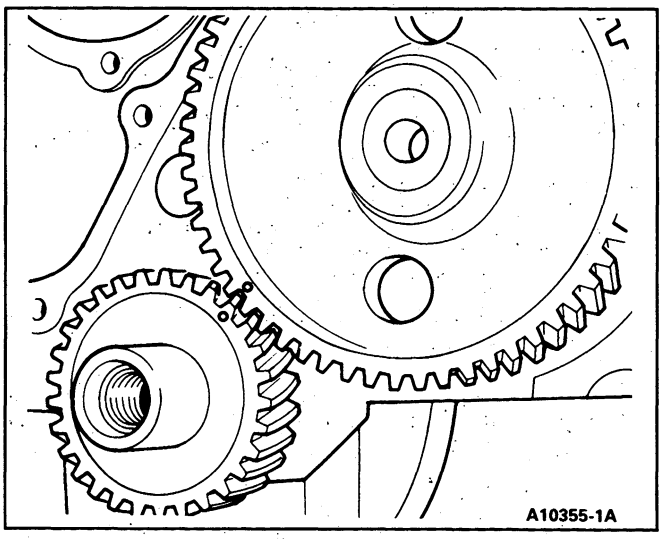


FIG. 32 Aligning Timing Marks

Timing Gears

To prevent possible damage to the camshaft lobes, do not rotate the camshaft or crankshaft in the engine without the timing gears installed.

Camshaft Gear

Removal

1. Drain the cooling system and crankcase.
2. Remove the cylinder front cover following the procedures under Cylinder Front Cover Removal.

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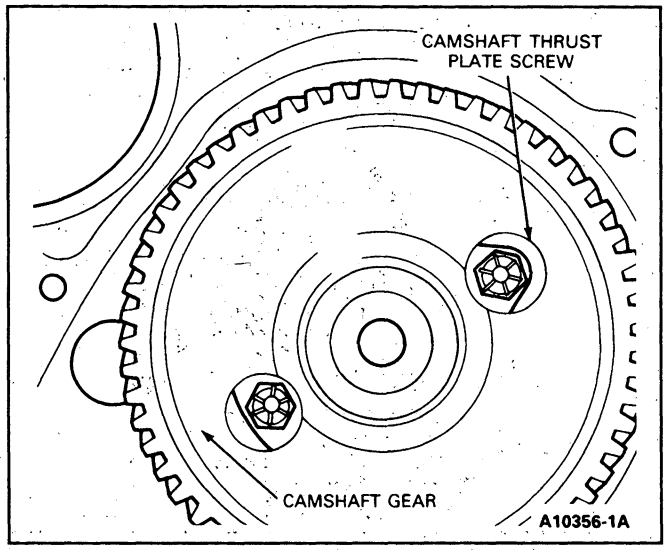


FIG. 33 Removing or Installing Camshaft

3. Check the camshaft end play, the timing gear backlash and the timing gear runout. Refer to Section 21-01, General Gasoline Engine Service.
4. Crank the engine until the timing marks are aligned as shown in Fig. 32.
5. Install the Camshaft Gear Puller T82T-6256-A or equivalent as shown in Fig. 34 and remove the camshaft gear.

Installation

If the camshaft end play, timing gear backlash and/or timing gear runout were excessive, make the necessary corrections before installing the gear.

1. Ensure the key spacer and thrust plate are properly installed. Align the gear keyway with the key and install the gear on the camshaft using Camshaft Gear Replacing Adapter T65L-6306-A or equivalent (Fig. 35). Ensure that the timing marks line up on the camshaft and crankshaft gears.
2. Install the cylinder front cover and related parts following the procedures under Cylinder Front Cover Installation.
3. Fill the crankcase and cooling system. Refer to Section 27-02, Cooling System Service. Start the engine and adjust the ignition timing. Operate the engine at fast idle and check all hose connections and gaskets for leaks.

Crankshaft Gear

Removal

1. Drain the cooling system and crankcase. Remove the radiator. Refer to Section 27-04, Radiators.
2. Remove the cylinder front cover.
3. Crank the engine until the timing marks are aligned as shown in Fig. 32.
4. Use Crankshaft Damper Remover T58P-6316-D or equivalent as shown in Fig. 36 and remove the crankshaft gear. Remove the key from the crankshaft.

Installation

1. Install the key in the crankshaft keyway. Install the crankshaft gear using the Crankshaft Damper Replacer T52L-6306-AEE or equivalent shown in Fig. 37. Ensure timing marks are aligned properly on the camshaft and crankshaft gears. Install the oil slinger.
2. Replace the crankshaft front oil seal. Install the cylinder front cover following the procedures under Cylinder Front Cover.
3. Install the radiator. Refer to Section 27-04, Radiators.
4. Fill the crankcase and the cooling systems. Refer to Section 27-02, Cooling System Service. Start the engine and check all gaskets and hose connections for leaks. Adjust the ignition timing and curb idle to the specifications on the engine decal.

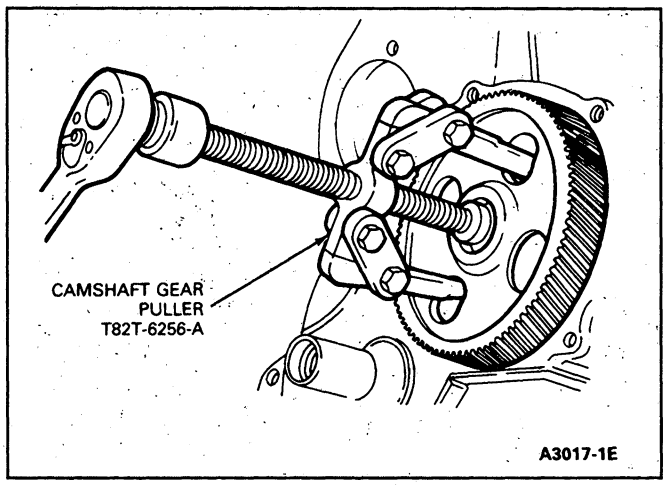


FIG. 34 Removing Camshaft Gear

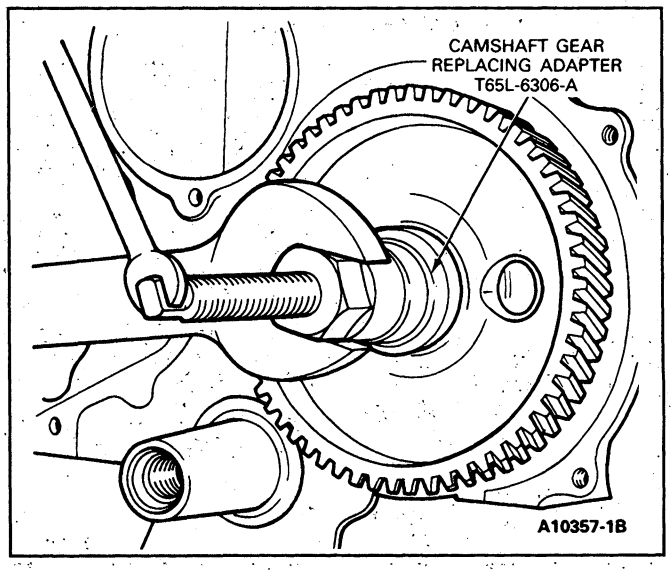


FIG. 35 Installing Camshaft Gear

Flywheel

Removal

1. Remove the transmission following the procedure in Group 16 (Clutch and Manual Transmission) or Group 17 (Automatic Transmission).
2. On a manual transmission, remove the clutch pressure plate and cover assembly and clutch disc following the procedure in Group 16.

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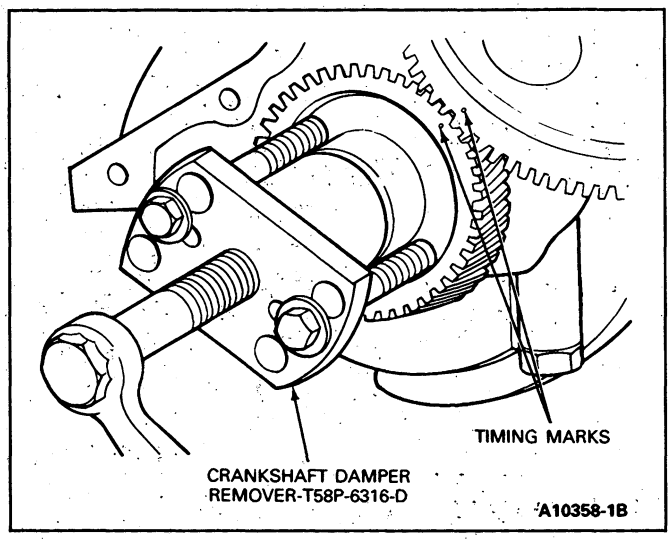


FIG. 36 Removing Crankshaft Gear

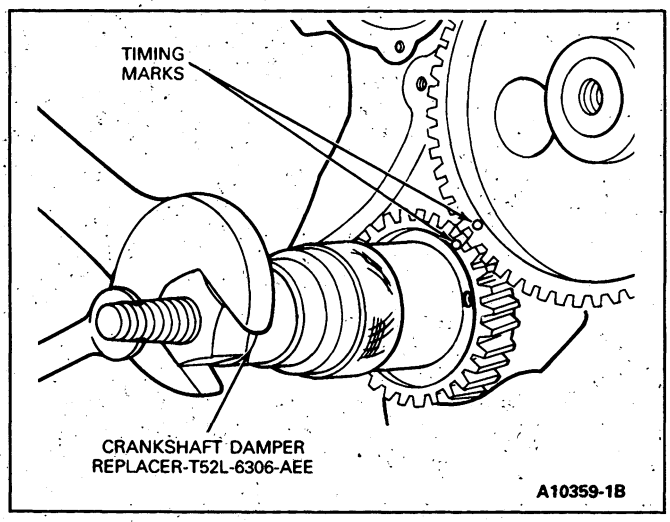


FIG. 37 Installing Crankshaft Gear

3. Remove the flywheel attaching bolts and remove the flywheel.

   To check flywheel face runout or replace the flywheel ring gear, refer to Section 21-01, General Gasoline Engine Service.

Installation

1. Position the flywheel on the crankshaft flange. Coat the threads of the flywheel attaching bolts with oil-resistant sealer and install the bolts. Tighten the bolts in sequence across from each other to 102-115 N·m (75-85 ft-lb).
2. On a manual transmission, install the clutch disc and the pressure plate and cover assembly. Refer to Group 16.
3. Install the transmission. Refer to Group 16 or Group 17.

Clutch Pilot Bearings

A needle roller bearing and adaptor assembly is used as a clutch pilot bearing on E-150—E-350, F-150—F-350, and Bronco vehicles (Fig. 38). It is inserted directly into the engine crankshaft. The bearing and adapter assembly cannot be serviced separately. The needle bearing clutch pilot can only be installed

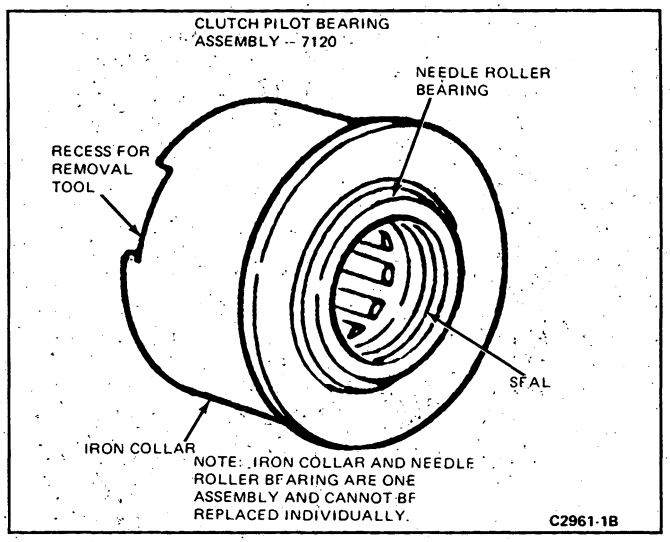


FIG. 38 Clutch Pilot Bearing Assembly

with the seal end of the bearing facing the transmission. The bearing and seal are pregreased and do not require additional lubrication. A new bearing must be installed whenever a bearing is removed. For additional information refer to Section 16-02, Clutch.

Removal

1. Remove the transmission, clutch pressure plate, and disc. Refer to Group 16.
2. Using the Impact Slide Hammer T59L-100-B and Puller Attachment T58L-101-AB or equivalents, remove the pilot bearing (Fig. 39).

Installation

1. Using Pilot Bearing Replacer T74P-7137-A or equivalent, install the pilot bearing with the seal facing the transmission (Fig. 40) so that the adaptor is not cocked.
2. Install the clutch pressure plate, disc, and transmission. Refer to Group 16.

   NOTE: Care must be taken not to damage the bearing while the transmission input shaft is being inserted into the bearing during transmission installation.

Camshaft Rear Bearing Bore Plug

Removal

1. Remove the transmission and flywheel housing. Refer to Group 16 (Manual Transmission) or Group 17 (Automatic Transmission). On a manual transmission, remove the clutch pressure plate and disc. Refer to Section 16-02.
2. Remove the flywheel attaching bolts. Remove the flywheel and the engine rear cover plate.
3. Refer to Section 21-01, General Gasoline Engine Service to remove the core plug.

Installation

1. Replace the core plug. Refer to Section 21-01, General Gasoline Engine Service.
2. Install the engine rear cover plate and flywheel. Coat the flywheel attaching bolts with Pipe Sealant with Teflon® D8AZ-19554-A or equivalent. Tighten the flywheel bolts in sequence to 102-115 N·m (78-85 ft-lb).

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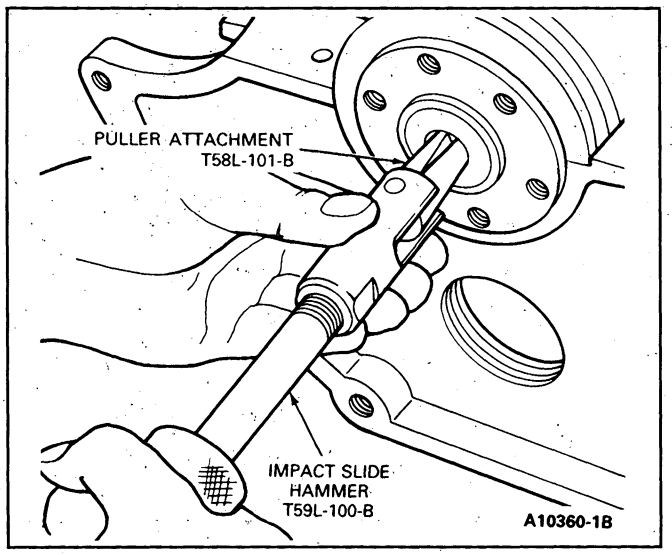


FIG. 39 Removing Clutch Pilot Bearing Assembly

On a vehicle with a manual transmission, install the clutch pressure plate and disc and transmission. Refer to Group 16.

On a vehicle with an automatic transmission, install the transmission and converter housing. Refer to Group 17.

Crankshaft Rear Oil Seal

For crankshaft rear oil seal replacement refer to One-Piece Rear Oil Seal, Removal and Installation in Section 21-01, General Gasoline Engine Service.

Main Bearing

Do not file or lap bearing caps or use shims to obtain the proper bearing clearance.

Bearings are available for service in standard sizes or 0.001 and 0.002 inch undersize. Refer to the Parts Catalog for the available sizes. Undersize bearings are available for use on journals that have been refinished.

If the rear main bearing is to be replaced, it will be necessary to remove the engine, install it on a work stand (Fig. 41), replace the main bearing and replace the crankshaft rear oil seal.

Removal

1. Drain the crankcase. Remove the oil pan and oil pump following the procedure under Oil Pan Removal.
2. **Replace one bearing at a time, leaving the other bearings securely fastened.** Remove the main bearing cap to which new bearings are to be installed.

   NOTE: Loosen all main bearing caps until finger-tight. This will lower the crankshaft and ease installation of new bearings.
3. Insert Main Bearing Insert Tool TOOL-6331-E in the oil hole in the crankshaft journal (Fig. 42).
4. Rotate the crankshaft in the direction of engine rotation to force the bearing out of the block.
5. Clean the crankshaft journal. When replacing standard bearings with new bearings, it is good practice to first try to obtain the proper clearance with standard bearings or a combination of a standard bearing and a 0.001 or 0.002 inch undersize bearing.

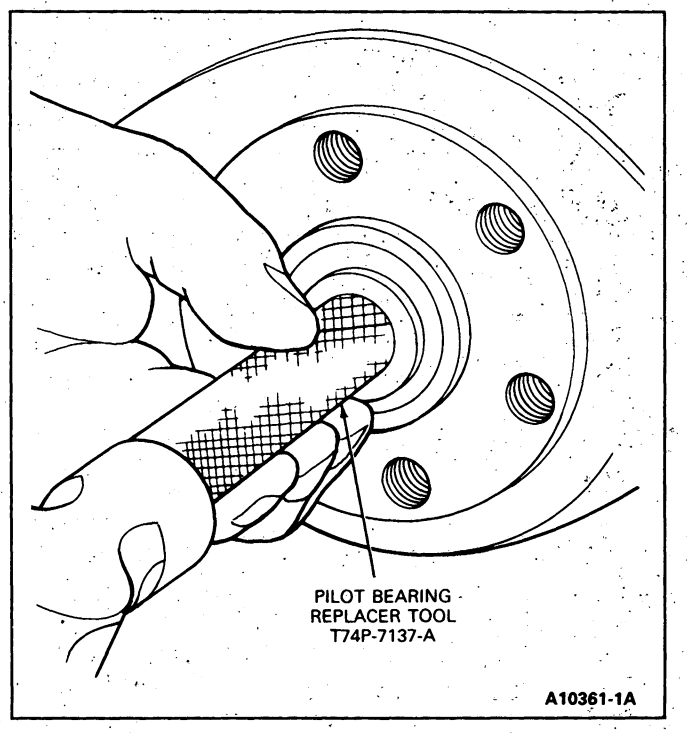


FIG. 40 Installing Clutch Pilot Bearing Assembly

Installation

1. **The upper and lower bearing halves are not interchangeable. The upper half is drilled and grooved to provide entry of oil.** Be sure bearings and surfaces are clean. Foreign material under the inserts will distort the bearings and cause failure.

   To install the upper main bearing, place the plain end of the bearing over the shaft on the locking tang side of the block and partially install the bearing so that Main Bearing Insert Tool TOOL-6331-E can be inserted in the oil hole in the crankshaft journal (Fig. 42). With Main Bearing Insert Tool TOOL-6331-E positioned in the oil hole, rotate the crankshaft slowly in the opposite direction of engine rotation until the bearing is seated. Remove the tool.

   Select-fit the bearing for proper clearance. Refer to Fitting Main and Connecting Rod Bearings in Section 21-01, General Gasoline Engine Service.
2. After the bearing has been fitted, apply a light coat of engine oil to the journal and bearings. Then, install the bearing cap. Tighten the cap bolts to 82-94 N·m (60-70 ft-lb).
3. Repeat the procedure for the remaining bearings that require replacement.
4. If the thrust bearing cap (No. 5 main bearing) has been removed, install it as follows:

   Install the thrust bearing cap with the bolts finger-tight. Pry the crankshaft forward against the thrust surface of the upper half of the bearing (Fig. 43). Hold the crankshaft forward and pry the thrust bearing cap to the rear. This will align the thrust surfaces of both halves of the bearing. Retain the forward pressure on the crankshaft. Tighten the cap bolts to 82-94 N·m (60-70 ft-lb).

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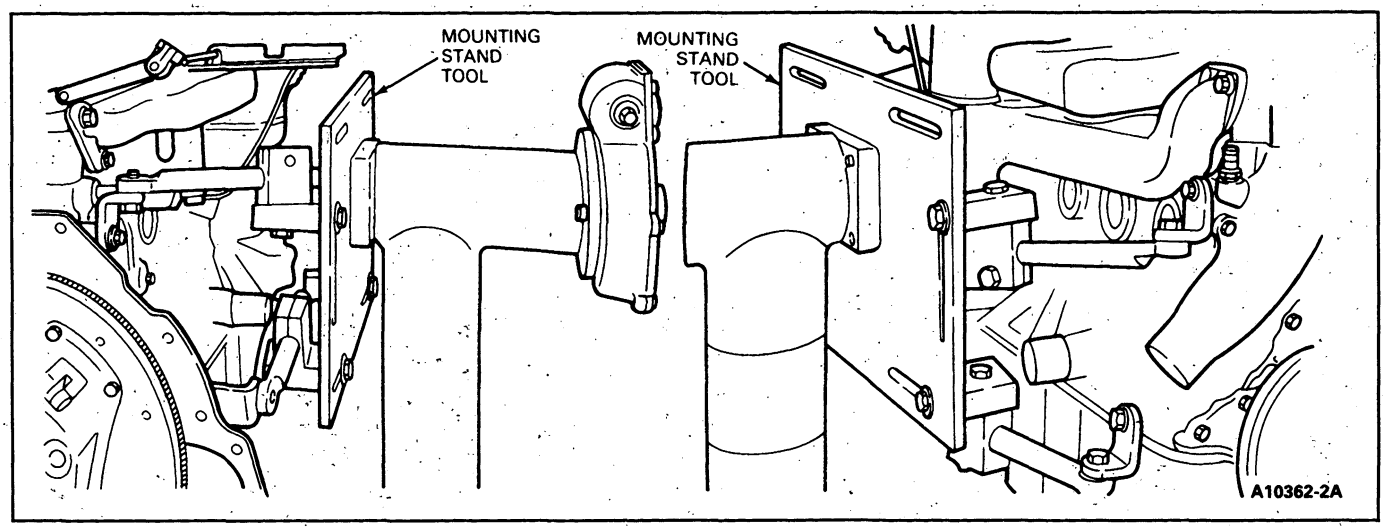


FIG. 41 Engine Mounted on Work Stand—Typical

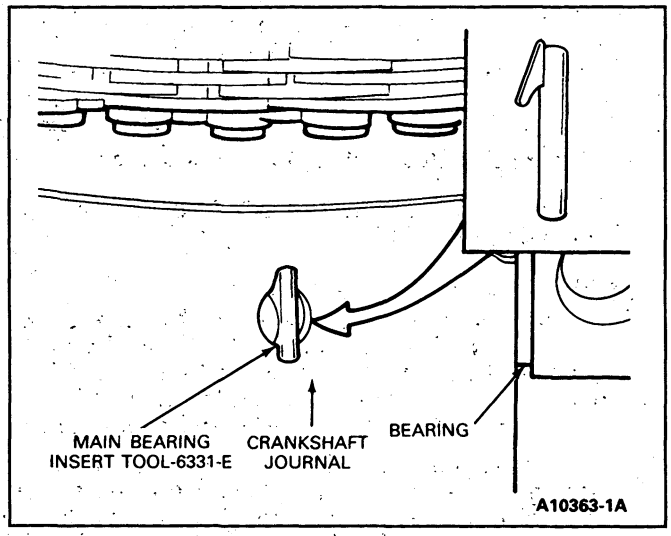


FIG. 42 Removing or Installing Upper Main Bearing Insert

5. If the rear main bearing is replaced (on a work stand), clean the mating surfaces of the bearing cap and the block with Ford Extra-Strength Spot and Stain Remover B7A-19521-AA or equivalent solvent. Apply a 1.6mm (1/16 inch) bead of RTV sealer, Silicone Rubber D6AZ-19562-BA or equivalent in each corner of the rear main bearing cap saddle the full length of the saddle. **Be sure the main bearing is fitted and the cap bolts tightened to 82-94 N·m (60-70 ft-lb) before installing the new crankshaft rear oil seal.**

   NOTE: When applying RTV sealant, always use the bead size specified and join the components within 15 minutes of application. After this amount of time the sealant begins to "set-up" and its sealing effectiveness may be reduced.

6. Clean the oil pump inlet tube screen. Prime the oil pump by filling the inlet opening with oil and rotate the pump shaft until the oil emerges from the outlet opening.

7. Install the oil pump and oil pan following the procedure under Oil Pan Installation

8. Fill the crankcase and cooling system. Refer to Section 10-02, Maintenance. Start the engine and check for oil pressure. Operate the engine at fast idle and check for oil and coolant leaks.

Connecting Rod Bearing

Removal

1. Drain the crankcase. Remove the oil pan and oil pump following the procedure under Oil Pan Removal.
2. Turn the crankshaft until the connecting rod to which new bearings are to be fitted is down. Remove the connecting rod cap. Remove the bearing inserts from the rod and cap.

   NOTE: If bearings are to be reused, identify them according to location so that they can be installed in their original positions.
3. Ensure the bearing inserts and the bearing bore in the connecting rod and cap are clean. Foreign material under the inserts will distort the bearing and cause a failure.
4. Clean the crankshaft journal. When replacing standard bearings with new bearings, it is good practice to first try to obtain the proper clearance with standard bearings. Refer to Section 21-01, General Gasoline Engine Service for the cleaning and inspection procedures.

Installation

1. Install the bearing inserts in the connecting rod and cap with the tangs fitted in the slots.
2. Pull the connecting rod assembly down firmly on the crankshaft journal.

   Fit the bearing. Refer to Section 21-01, General Gasoline Engine Service.
3. After the bearing has been fitted, clean and apply a light coat of engine oil to the journal and bearings. Install the connecting rod cap and tighten the nuts to 55-61 N·m (40-45 ft-lb).
4. Repeat the procedure for the remaining connecting rods that require new bearings.
5. Install the oil pan and oil pump following the procedures under Oil Pan Installation in this Section.

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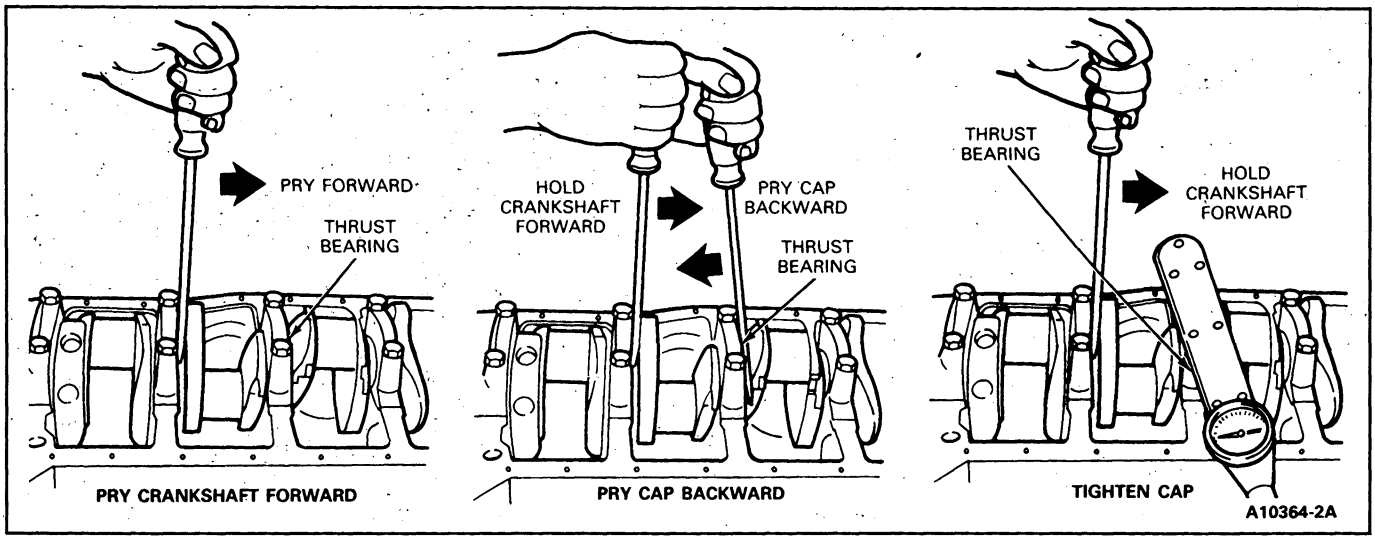


FIG. 43 Aligning Thrust Bearing

6. Fill the crankcase. Fill the cooling system. Refer to Section 27-02, Cooling System Service. Start the engine and check for oil pressure. Operate the engine at fast idle and check for oil and coolant leaks.

Pistons and Connecting Rods

Removal

1. Drain the cooling system and the crankcase. Refer to Section 27-02, Cooling System Service.
2. Refer to Cylinder Head Removal in this Section and remove the cylinder head and related parts.
3. Remove the oil pan following the procedure under Oil Pan Removal in this Section. Remove the oil pump inlet tube and the oil pump.
4. Turn the crankshaft until the piston to be removed is at the bottom of the stroke and place a cloth on the piston dome to collect the cuttings. Remove any ridge and/or deposits from the upper end of the cylinder bore with Cylinder Ridge Reamer T64L-6011-EA or equivalent. Follow the instructions furnished by the tool manufacturer. **Never cut into the ring travel area in excess of 0.74mm (1/32 inch) when removing ridges.**
5. Ensure all the connecting rod caps are marked so that they can be installed in their original positions. Remove the connecting rod cap.
6. Push the connecting rod and piston assembly out the top of the cylinder with the handle end of a hammer. Avoid damage to the crankshaft journal or the cylinder wall when removing the piston and rod.

Installation

1. Clean the oil pump inlet tube screen and the oil pan and block gasket surfaces.
2. Oil the piston rings, pistons and cylinder walls with light engine oil.
3. **Ensure pistons are installed in the same cylinders from which they were removed or to which they were fitted.** The connecting rods and bearing caps are numbered from 1 to 6 beginning at the front of the engine. The number on the connecting rod and bearing cap must be on the same side of rod when installing in the cylinder bore. If a connecting rod is ever transferred from one cylinder block to another or from one cylinder to another, new bearings should be fitted and the connecting rod should be re-numbered to correspond with the new cylinder number.
4. Make sure the ring gaps (oil ring spacer -A, oil ring segment -B, and compression ring -C) are properly spaced around the circumference of the piston (Fig. 44). Oil the rings, then install Piston Ring Compressor D81L-6002-C or equivalent on the piston. Make sure that the indentation in the dome of piston is toward the front. Then, push the piston into its bore with the handle end of a hammer until it is slightly below the top of the cylinder (Fig. 45). Be sure to guide the connecting rods to avoid damaging the crankshaft journals.
5. Check the clearance of each bearing following the procedure under Fitting Main or Connecting Rod Bearing in Section 21-01, General Gasoline Engine Service.
6. After the bearings have been fitted, apply a light coat of engine oil to the journals and bearings.
7. Turn the crankshaft throw to the bottom of its stroke. Then, push the piston all the way down until the connecting rod bearing seats on the crankshaft journal. Install the connecting rod cap. Tighten the nuts to 55-61 N·m (40-45 ft-lb).
8. After the piston and connecting rod assemblies have been installed, check the connecting rod side clearance on each crankshaft journal (Fig. 46).
9. Prime the oil pump by filling the inlet opening with oil and rotate the pump shaft until oil emerges from the outlet opening. Install the oil pump and the oil pump inlet tube. Install the oil pan and related parts as outlined.
10. Refer to Cylinder Head Installation and install the cylinder head and related parts. Adjust the valve clearance as outlined.
11. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service. Fill the crankcase.
12. Start the engine and check for oil pressure. Operate the engine at fast idle and check for oil and coolant leaks.

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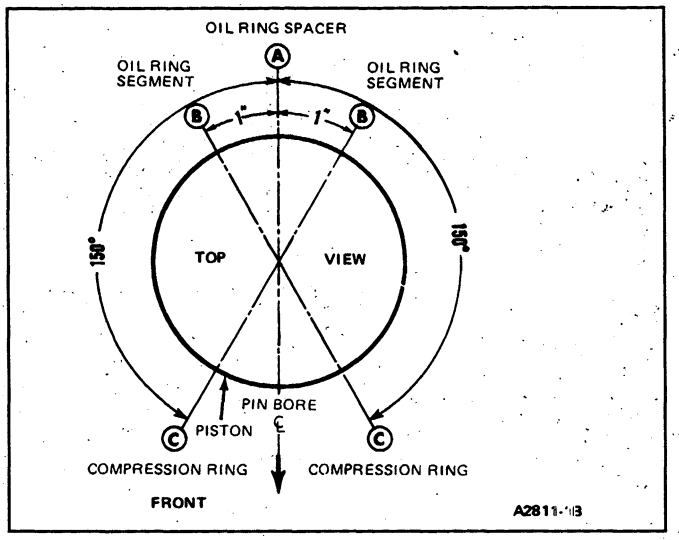


FIG. 44 Piston Ring Gap Spacing

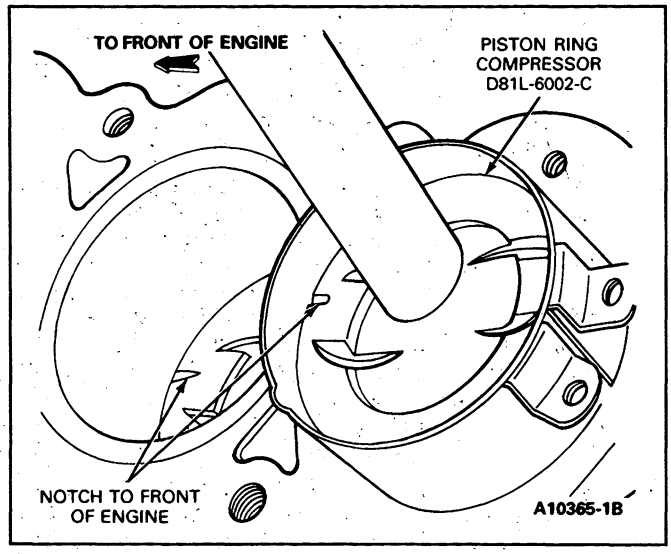


FIG. 45 Piston Installation

13. Operate the engine until engine temperatures have stabilized. Check and adjust the ignition timing.

    On a vehicle with an automatic transmission, adjust the transmission control linkage. Refer to Section 17-02, Shift Control Linkage.

Crankshaft

The crankshaft and related parts are shown in Fig. 47.

Removal

1. Install the engine on a work stand. Remove the spark plugs to allow easy rotation of the crankshaft. Drain the crankcase.
2. Remove the oil level dipstick.
3. Remove the crankshaft damper attaching bolt and lockwasher. Remove the crankshaft damper (Fig. 22).
4. Remove the cylinder front cover and gasket.
5. Remove the flywheel and engine rear cover plate.
6. Turn the engine on the work stand so that the bottom of the engine is up. Remove the oil pan, gaskets and seals. Remove the oil pump and inlet tube assembly. Discard the oil pump gasket.
7. **Make sure all bearing caps (main and connecting rod) are marked so that they can be installed in their original locations.** Turn the crankshaft until the connecting rod from which the cap is being removed is at the bottom of the stroke. Remove the connecting rod cap and bearings. Push the connecting rod and piston assembly up in the cylinder. **Do not turn the crankshaft completely around as the rod bolts may damage the crankpin journals.** Repeat this procedure and remove all connecting rod caps.
8. Remove the clutch pilot bearing if necessary.
9. Align the timing marks (Fig. 32). Remove the crankshaft gear as outlined (Fig. 36).
10. Remove the main bearing caps and bearings and rear bearing seal.
11. Carefully lift the crankshaft out of the cylinder block so that the thrust bearing surfaces are not damaged. **Handle the crankshaft with care to avoid possible fracture or damage to the finished surfaces.**

    Refer to Section 21-01, General Gasoline Engine Service for the cleaning and inspection procedures. Be sure the oil seal surfaces on the crankshaft and crankshaft damper are properly cleaned.

    To refinish journals and dress minor imperfections, refer to Section 21-01, General Gasoline Engine Service.

Installation

1. Remove the main bearing inserts from the block and bearing caps.
2. Remove the bearing inserts from the connecting rod caps.
3. Clean the crankshaft rear oil seal recess in the cylinder block and rear main bearing cap.
4. If the crankshaft main bearing journals have been refinished to a definite undersize, install the correct undersize bearings. Be sure the bearing inserts and bearing bores are clean. Foreign material

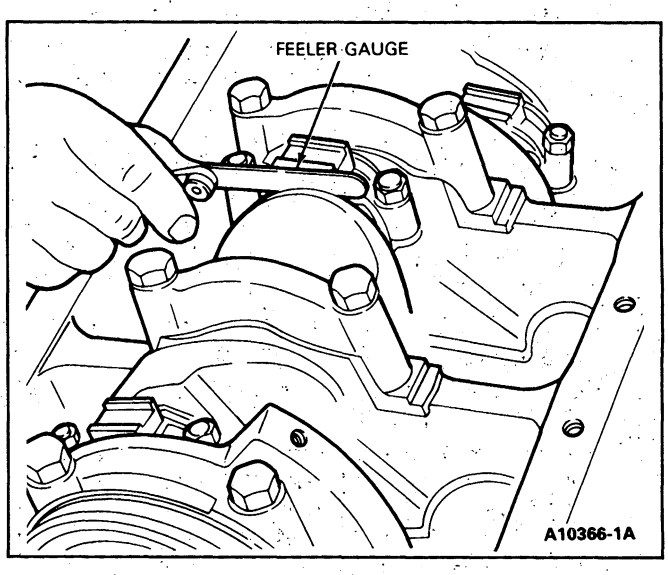


FIG. 46 Checking Connecting Rod Side Clearance

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under the inserts will distort the bearing and cause a failure.

5. Place the upper main bearing inserts in position in the bore with the tang fitting in the slot provided. Be sure the oil holes in the bearing inserts are aligned with the oil holes in the cylinder block.
6. Install the lower main bearing inserts in the bearing caps with the tang fitted in the slot.
7. Carefully lower the crankshaft into place. **Be careful not to damage the bearing surfaces.**
8. Check the clearance of each main bearing. Refer to Section 21-01, General Gasoline Engine Service under Fitting Main and Connecting Rod Bearings. Seal the rear main bearing-to-block mating surfaces as directed in Main Bearing Installation.
9. After the bearings have been installed, apply a light coat of heavy engine oil to the journals and bearings. Install all the bearing caps, except the thrust bearing cap (No. 5 bearing). **Be sure that the main bearing caps are installed in their original locations.** Tighten the bearing cap bolts to 82-94 N·m (60-70 ft-lb).
10. Install the thrust bearing cap with the bolts finger-tight.
11. Pry the crankshaft forward against the thrust surface of the upper half of the bearing (Fig. 43).
12. Hold the crankshaft forward and pry the thrust bearing cap to the rear. This will align the thrust surfaces of both halves of the bearing.
13. Retain the forward pressure on the crankshaft. Tighten the cap bolts to 82-94 N·m (60-70 ft-lb).
14. Check the crankshaft end play. Refer to Section 21-01, General Gasoline Engine Service.
15. If the end play exceeds the service limit, replace the thrust bearing. If the end play is less than the minimum limit, inspect the thrust bearing faces for scratches, burrs, nicks or foreign matter. If the thrust faces are not damaged or dirty, they probably need re-aligning. Install the thrust bearing and align the faces following the recommended procedure (Steps 10 through 13 above). Then, check the end play.
16. Coat a new crankshaft rear oil seal with oil and install using Rear Oil Seal Replacer T65P-6701-A or equivalent. Refer to One-Piece Rear Oil Seal Installation in Section 21-01, General Gasoline Engine Service. Inspect the seal to be sure it was not damaged during installation.
17. Install the bearing inserts in the connecting rods and caps. Check the clearance of each bearing following the procedure under Connecting Rod Bearing Replacement.
18. If the bearing clearances are to specifications, apply a light coat of engine oil to the journals and bearing.
19. Turn the crankshaft throw to the bottom of its stroke and pull the piston all the way down until the connecting rod bearing seats on the crankshaft journal.
20. Install the connecting rod cap and tighten the nuts to specifications.
21. After the piston and connecting rod assemblies have been installed, check the connecting rod side clearance on each crankshaft journal (Fig. 46). Refer to Specifications.
22. Clean the oil pan, oil pump and oil pump screen.

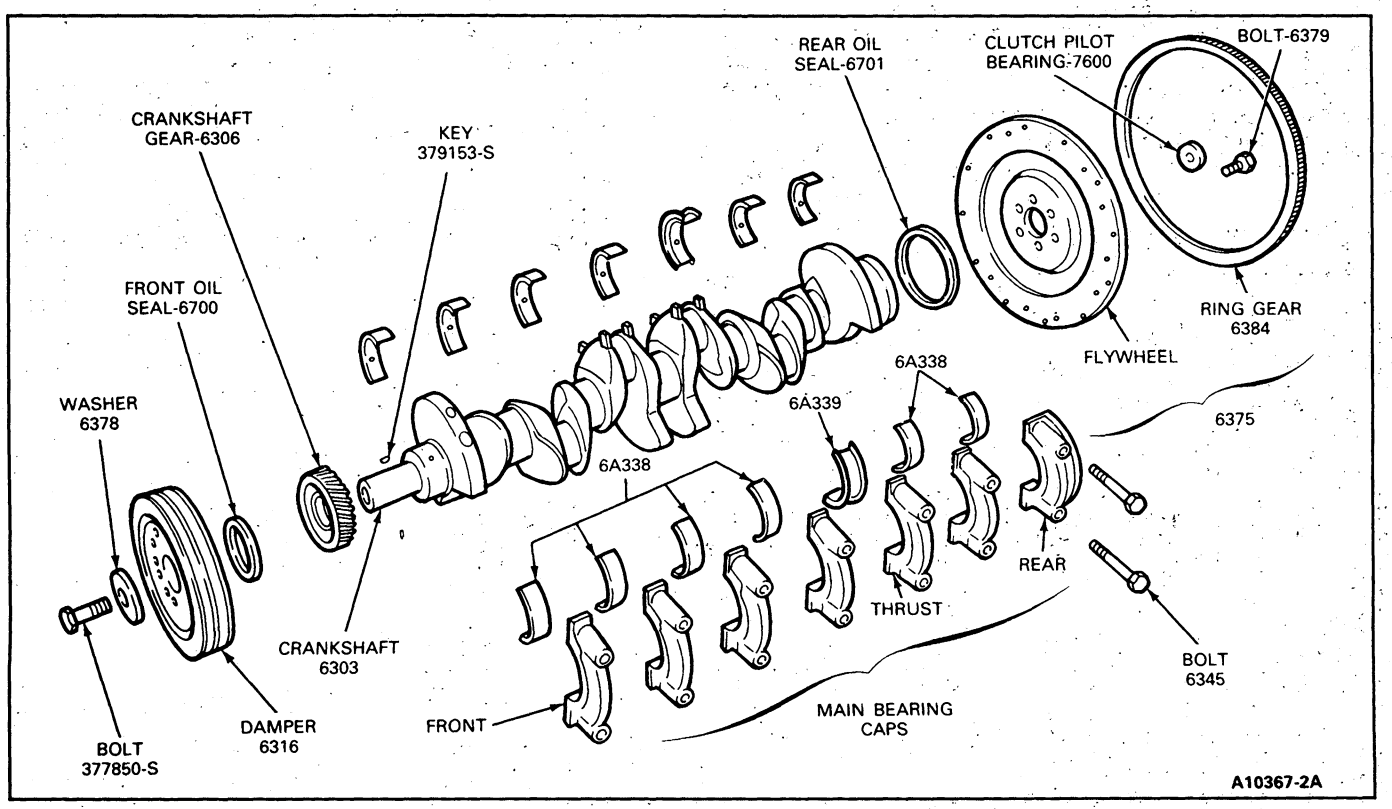


FIG. 47 Crankshaft and Related Parts

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23. Install the inlet tube and screen on the oil pump. Prime the oil pump by filling the inlet opening with oil and rotate the pump shaft until oil emerges from the outlet opening. Install the oil pump. Tighten the attaching bolts to 14-20 N·m (10-15 ft-lb).
24. On a crankshaft for a manual transmission, install the clutch pilot bearing. Refer to Clutch Pilot Bearing Removal and Installation.
25. Turn the engine on the work stand so that the rear of the engine is up. Position the engine rear cover plate on the cylinder block. Position the flywheel on the crankshaft. **Coat the threads of the attaching bolts with Pipe Sealant with Teflon® D8AZ-19554-A or equivalent oil-resistant sealer and install the bolts.** Tighten the bolts to 102-115 N·m (75-85 ft-lb).

    On a flywheel for a manual transmission, locate the clutch disc following the procedure in Group 16. Install the pressure plate. Tighten the attaching bolts to 102-115 N·m (75-85 ft-lb).
26. Turn the engine on the work stand so that the front end is up.
27. Install the crankshaft gear following the procedure under Timing Gear Installation.
28. Install a new grease-coated crankshaft front oil seal in the cylinder front cover using Front Cover Seal Replacer T70P-6B070-A or equivalent (Fig. 27). Install the cylinder front cover and crankshaft damper by following the procedure outlined under Cylinder Front Cover Installation.
29. Apply Perfect Seal Sealing Compound B5A-19554-A or equivalent oil-resistant sealer in the cavities between the rear bearing cap and cylinder block (Fig. 28). Install a new seal in the rear main bearing cap and apply a bead of Perfect Seal Sealing Compound B5A-19554-A or equivalent oil-resistant sealer to the tapered ends of the seal. Install new side gaskets on the oil pan with Gasket and Seal Contact Adhesive or equivalent oil-resistant sealer (Fig. 28). Position a new oil pan-to-cylinder front cover seal on the oil pan and install the oil pan.
30. Install the oil level dipstick.
31. Remove the engine from the work stand and install it in the vehicle. Fill the crankcase. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service.
32. Start the engine and check all gaskets and hose connections for leaks.
33. Check the ignition timing and adjust to specifications on the engine decal.

Camshaft Bearings

Camshaft bearings are available prefinished to size for standard and 0.381mm (0.015 inch) undersize journal diameters.

Removal

1. Remove the engine and install on a work stand (Fig. 41).
2. Remove the camshaft, flywheel and crankshaft. Push the pistons to the top of the cylinders.
3. Remove the camshaft rear bearing bore plug. Refer to Section 21-01, General Gasoline Engine Service. Remove the camshaft bearings with Camshaft Bearing Set T65L-6250-A or equivalent (Fig. 48).
4. Select the proper size expanding collet and backup nut and assemble on the expanding mandrel. With the expanding collet collapsed, install the collet assembly in the camshaft bearing and tighten the backup nut on the expanding mandrel until the collet fits the camshaft bearing.
5. Assemble the puller screw and extension, if necessary, as shown and install on the expanding mandrel. Wrap a cloth around the threads of the puller screw to protect the front bearing or journal. Tighten the pulling nut against the thrust bearing and pulling plate to remove the camshaft bearing. Be sure to hold a wrench on the end of the puller screw to prevent it from turning.
6. To remove the front bearing, install the puller screw from the rear of the cylinder block.

Installation

1. Position the new bearings at the bearing bores, and press them in place with Camshaft Bearing Set

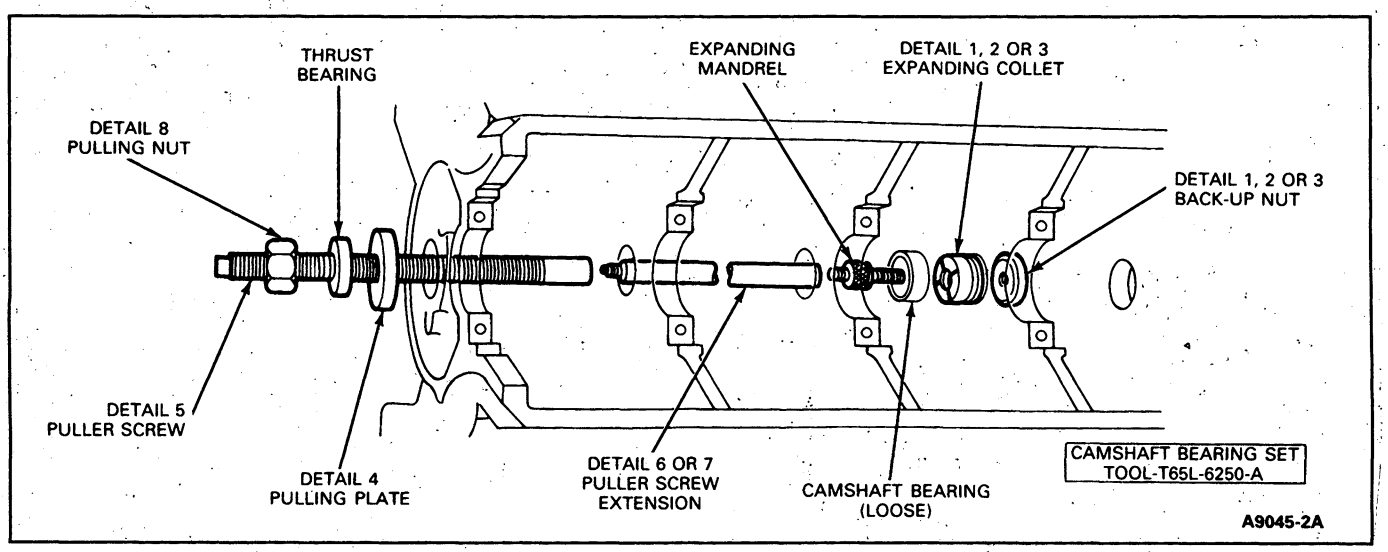


FIG. 48 Replacing Camshaft Bearing

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T65L-6250-A or equivalent (Fig. 48). Be sure to center the pulling plate and puller screw to avoid damage to the bearing. **Failure to use the correct expanding collet can cause severe bearing damage.** Align the oil holes in the bearings with the oil holes in the cylinder block before pressing bearings into place. **Be sure the front bearing is installed 0.51-0.89mm (0.020-0.035 inches) below the front face of the cylinder block.**

2. Install the camshaft rear bearing bore plug. Refer to Section 21-01, General Gasoline Engine Service.
3. Install the camshaft, crankshaft, flywheel and related parts. Do not check connecting rod and main bearing clearances as a part of camshaft bearing replacement.
4. Install the engine in the vehicle.

Oil Filter

Removal

1. Place a drip pan under the oil filter. Unscrew the filter from the cylinder block using Oil Filter wrench D79L-6731-A, B or equivalents.

Installation

1. Coat the gasket on the filter with oil. Place the filter in position on the cylinder block. Hand-tighten the filter until the gasket contacts the adapter face, then advance it one-half turn.
2. Operate the engine at fast idle and check for oil leaks. If oil leaks are evident, perform the necessary repairs to correct the leakage. Check the oil level and fill the crankcase if necessary.

DISASSEMBLY AND ASSEMBLY

When installing nuts or bolts that must be tightened, oil the threads with light weight engine oil. **Do not oil threads that require oil-resistant or water-resistant sealer.**

Cylinder Head

Disassembly

1. Remove the coolant outlet housing and thermostat. Discard the gasket.
2. Remove the upper intake and throttle body assembly.
3. Remove the lower intake manifold and exhaust manifold from the cylinder head. Discard the gasket.
4. Remove the spark plugs.
5. Remove the deposits from the combustion chambers and valve heads with a scraper and a wire brush before removing the valves. **Be careful not to scratch the cylinder head gasket surface.**
6. Compress the valve springs using Valve Spring Compressor T70P-6049-A or equivalent (Fig. 49), then remove the valve spring retainer locks and release the spring.
7. Remove the spring retainer, spring, stem seal and valve (Fig. 50). Discard the valve stem seals.

Assembly

1. Lubricate the valve guides and valve stems with heavy engine oil. Apply Multi-Purpose Grease D0AZ-19584-AA or equivalent to the tip of the valve stems.
2. Install each valve in the valve guide from which it was removed or to which it was fitted.
3. Oil and install a new stem valve oil seal (Fig. 50).
4. Install the valve spring over the valve. **Ensure the closed coil end is placed against the cylinder head.**
5. Position the spring retainer on all valve springs. Make sure that a positive rotating retainer is used on all of the exhaust valves (Fig. 50).
6. Compress the spring (Fig. 49). Install the keys. Tap the retainers after assembly to seat the keys.
7. Measure the assembled height of the valve spring from the surface of the cylinder head spring pad to the underside of the spring retainer with dividers (Fig. 51).

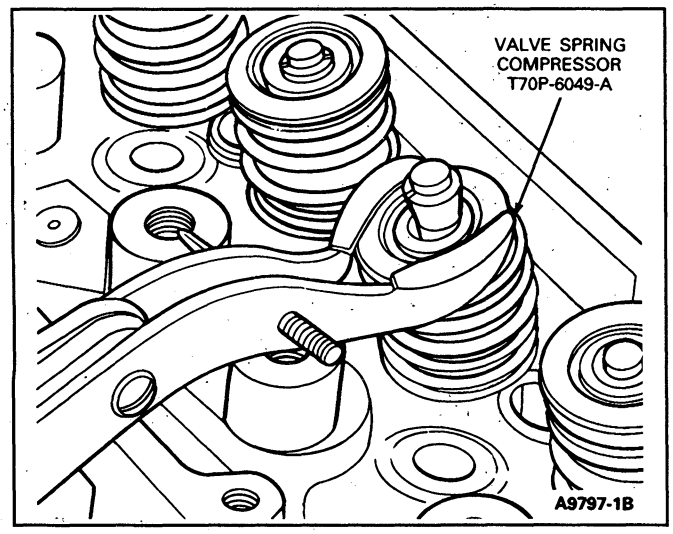


FIG. 49 Compressing Valve Spring on Bench

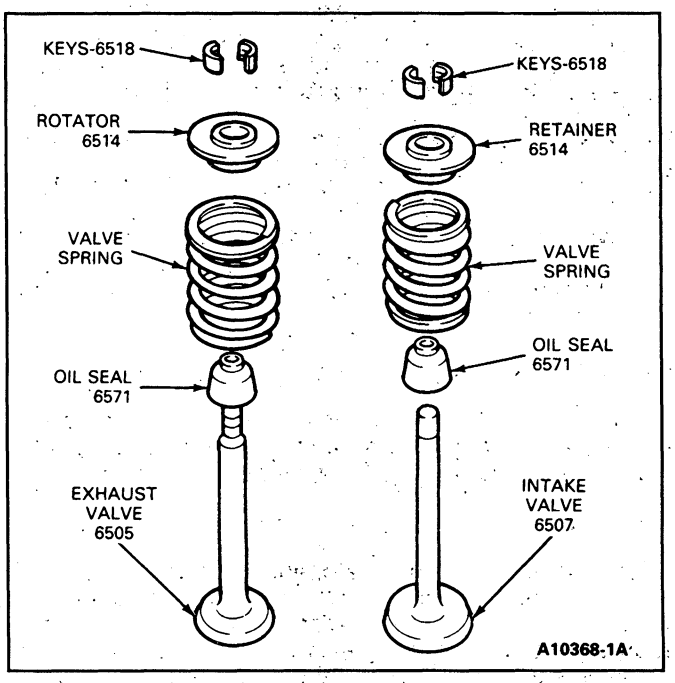


FIG. 50 Valve Assembly

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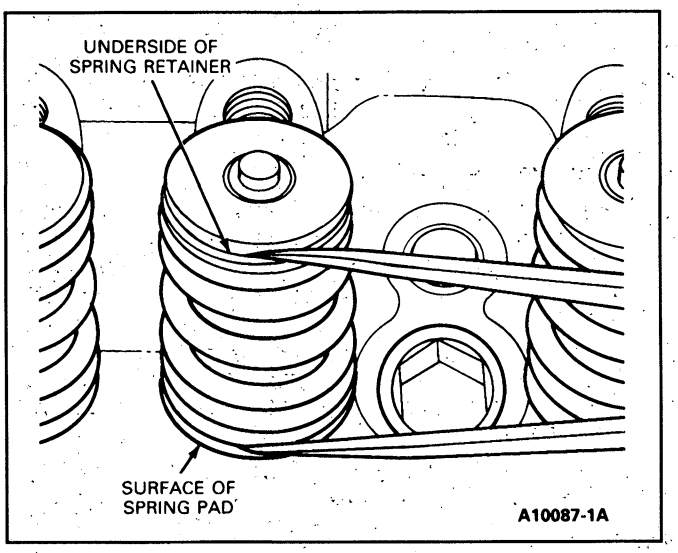


FIG. 51 Checking Valve Spring Assembled Height—Typical

Check the dividers against a scale. If the assembled height is greater than the specified limit, install the necessary 0.76mm (0.030-inch) thick spacer(s) between the cylinder head spring pad and the valve spring to bring the assembled height to the recommended dimension. **Do not install spacers unless necessary. Use of spacers in excess of recommendations will result in overstressing the valve springs and overloading the camshaft lobes which could lead to spring breakage and worn camshaft lobes.**

8. Position a new Intake Manifold Gasket on the cylinder head. Install the lower and intake manifold, exhaust manifolds. Tighten the manifold bolts and nuts in sequence (Fig. 20) to 30-43 N·m (22-32 ft-lb)—intake manifold, 38-44 N·m (28-33 ft-lb)—exhaust manifold.

NOTE: Combination intake/exhaust gasket is not to be used on a new exhaust manifold. Gasketing of the exhaust manifold is only recommended when the original exhaust manifold is installed.

9. Install the upper intake and throttle body assembly.

10. Using a new gasket coated with Perfect Seal Sealing Compound B5A-19554-A or equivalent water-resistant sealer, install the thermostat and coolant outlet elbow. Refer to Section 27-04, Radiators. Tighten the attaching bolts to specifications.

Valve Tappet

Valve tappets should always be tested after assembly. Refer to the test procedures in Section 21-01, General Gasoline Engine Service.

Disassembly

Each valve tappet is a matched assembly. If the parts of one tappet are mixed with those of another, improper valve operation may result. Disassemble and assemble each tappet separately. Keep the tappet assemblies in proper sequence so that they can be installed in their original bores.

1. Grasp the lock ring with needlenose pliers to release it from the groove. It may be necessary to depress the plunger to fully release the lock ring.
2. Remove the push rod cup, metering valve (disc), plunger and spring.
3. Invert the plunger assembly and remove the check valve retainer by carefully prying up on it with a screwdriver. Remove the check valve (disc or ball check) and spring.

For the cleaning and inspection procedures, refer to Section 21-01, General Gasoline Engine Service.

Assembly

Refer to Fig. 52 for hydraulic valve tappet assembly.

1. Place the plunger upside down on a clean work bench.
2. Place the check valve (disc or ball check) in position over the oil hole on the bottom of the plunger. Set the check valve spring on top of the check valve (disc or ball check).
3. Position the check valve retainer over the check valve and spring. Push the retainer down into place on the plunger.
4. Place the plunger spring and then the plunger (open end up) into the tappet body.
5. Position the metering valve (disc) in the plunger and then place the push rod cup in the plunger.
6. Depress the plunger and position the closed end of the lock ring in the groove of the tappet body. With the plunger still depressed, position the open ends of the lock ring in the groove. Release the plunger and then depress it again to fully seat the lock ring.
7. Use the hydraulic valve tappet leakdown tester to fill the tappets with test fluid. Refer to Section 21-01, General Gasoline Engine Service.

Piston and Connecting Rod

Disassembly

1. Remove the bearing inserts from the connecting rod and cap.
2. Mark the pistons and pins to assure assembly with the same rod and installation in the same cylinder from which they were removed.

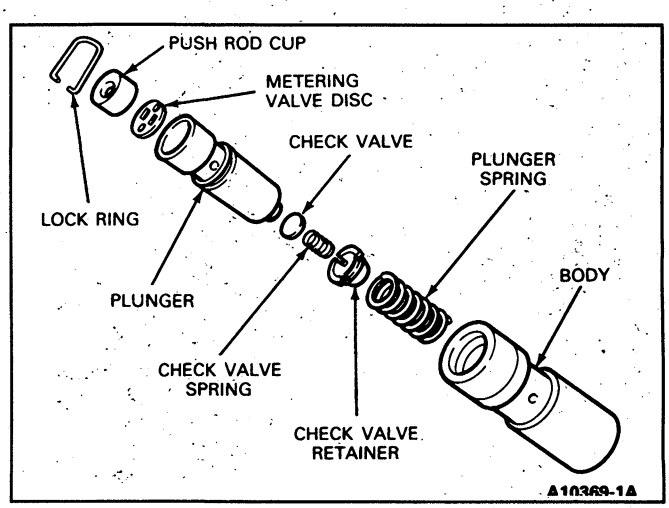


FIG. 52 Hydraulic Valve Tappet Assembly

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3. Remove the piston rings. Using an arbor press and Piston Pin Remover/Replacer T68P-6135-A or equivalent (Fig. 53), press the piston pin from the piston and connecting rod using Piston Pin Remover/Replacer Adapter T81P-6135-A or equivalent.

Refer to Section 21-01, General Gasoline Engine Service for Cleaning, Inspection and Repair procedures.

Assembly

The piston, connecting rod and related parts are shown in Fig. 54. **Check the fit of a new piston in the cylinder bore before assembling the piston and piston pin to the connecting rod. Refer to Section 21-01, General Gasoline Engine Service.**

The piston pin bore of a connecting rod and the diameter of the piston pin must be within specifications.

1. Apply a light coat of engine oil to all parts. **Assemble the piston to the connecting rod with the bearing tang side of the connecting rod and the indentation notch in the piston positioned as shown in Fig. 55.**
2. Start the piston pin in the piston and connecting rod. Using an arbor press, press the piston pin through the piston and connecting rod until the pin is centered in the connecting rod (Fig. 56). To install piston pin use either Piston Pin Remover/Replacer T68P-6135-A or equivalent.
3. Check the end gap of all piston rings. Refer to Section 21-01, General Gasoline Engine Service. It must be within specifications listed at end of this Section. Follow the instructions contained on the piston ring package and install the piston rings.
4. Check the ring side clearance of the compression rings with a feeler gauge inserted between the ring and its lower land. Refer to Section 21-01, General Gasoline Engine Service. The gauge should slide freely around the entire ring circumference without binding. Any wear that occurs will form a step at the inner portion of the lower land. **If the lower lands have steps, the piston should be replaced.**
5. Ensure the bearing inserts and the bearing bore in the connecting rod and cap are clean. Foreign material under the inserts will distort the bearing and cause a failure. Install the bearing inserts in the connecting rod and cap with the tangs fitting in the slots provided.

Cylinder Block

Before replacing a cylinder block, determine if it is repairable. If so, make the necessary repairs. Refer to Section 21-01, General Gasoline Engine Service.

Disassembly

1. Mount the old engine in a work stand and completely disassemble it, removing the cylinder head and manifolds as an assembly. Follow Engine Components Removal and Installation procedures.
2. Remember to ridge-ream the cylinder bores before removing the piston assemblies.
3. Remove the cylinder head locating dowels.

Assembly

1. Clean the gasket and seal surfaces of all serviceable parts and assemblies.

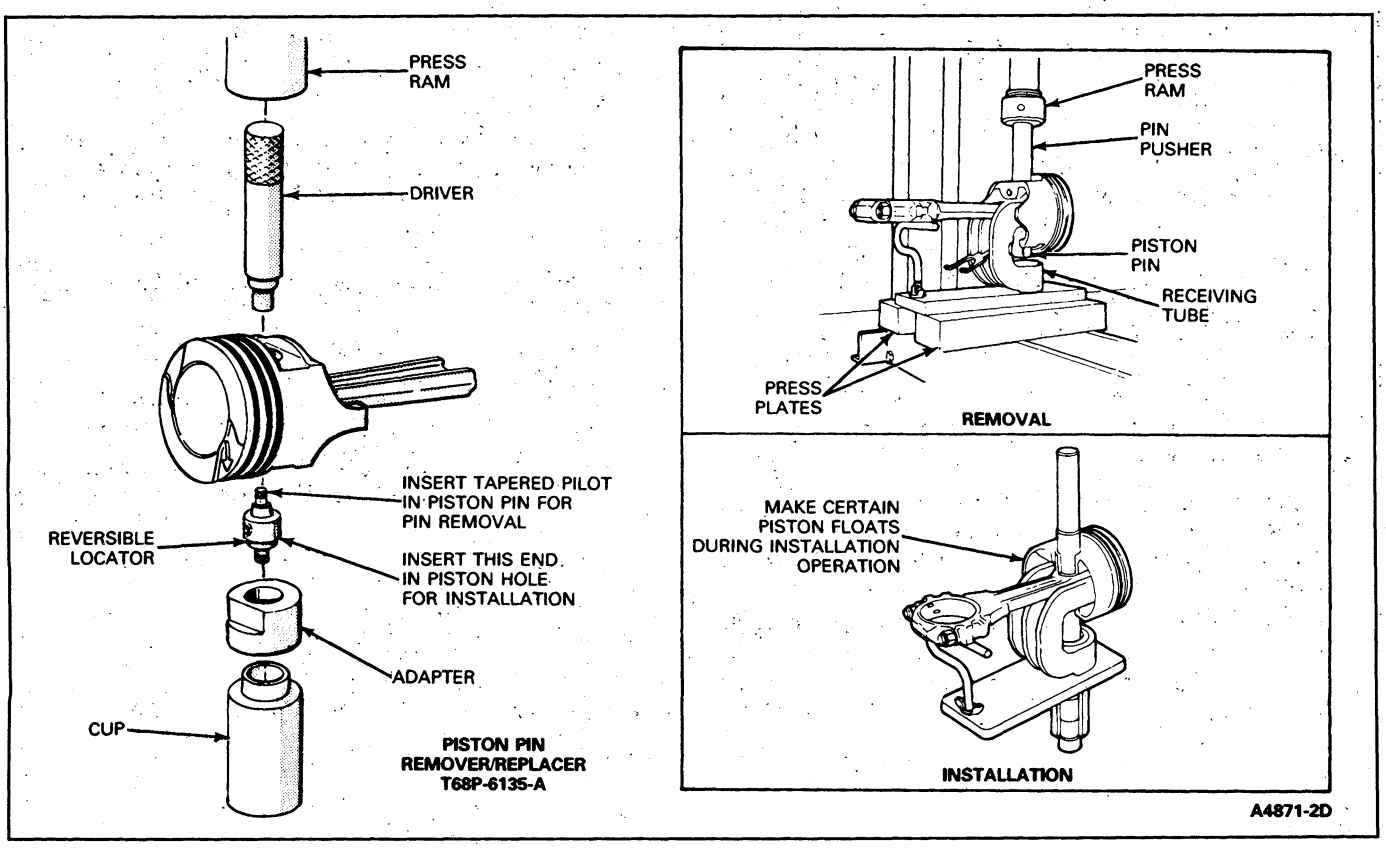


FIG. 53 Removing Piston Pin

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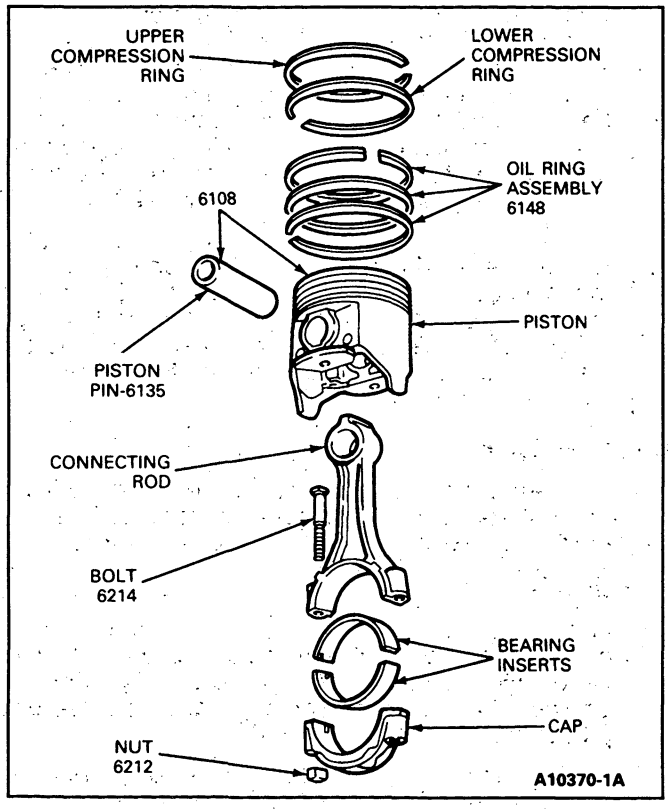


FIG. 54 Piston, Connecting Rod and Related Parts

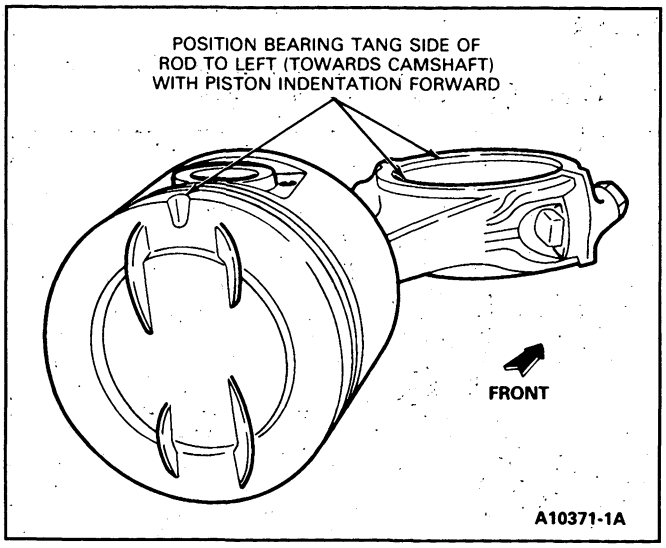


FIG. 55 Oil Hole Position

2. Position the new cylinder block in the work stand and transfer all serviceable parts removed from the old cylinder block following Engine Components Removal and Installation procedures.
3. Install the cylinder head locating dowels and block drain plugs.
4. Check all assembly clearances and correct as necessary.

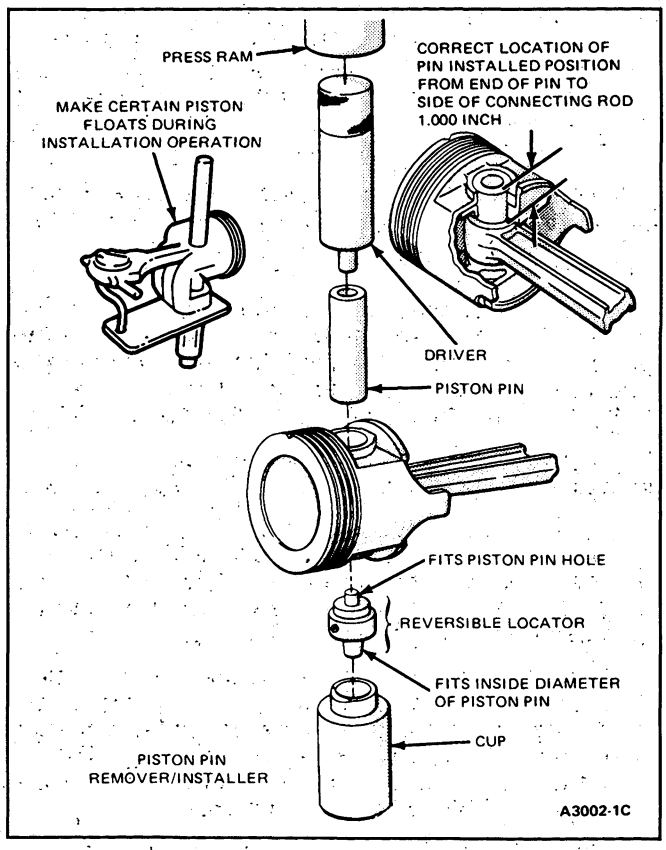


FIG. 56 Installing Piston Pin

Cylinder Assembly

Disassembly

1. Mount the old engine in a work stand.
2. Remove the cylinder head and manifolds as an assembly.
3. Remove all serviceable parts not furnished with the new cylinder assembly, including the cylinder block drain plugs and cylinder head locating dowels.

Assembly

1. Clean the gasket and seal surfaces of all serviceable parts and assemblies.
2. Position the new cylinder assembly in a work stand and transfer all serviceable parts removed from the old cylinder assembly following Engine Components Removal and Installation procedures.
3. Install the cylinder head locating dowels and block drain plugs. Install the cylinder head and manifolds as an assembly.
4. Check all assembly clearances and correct as necessary.

CLEANING AND INSPECTION

Refer to Cleaning and Inspection Procedures in Section 21-01, General Gasoline Engine Service.

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SPECIFICATIONS

GENERAL SPECIFICATIONS

Engine	Bore and Stroke	Firing Order	Oil Pressure Hot @ 2000 RPM kPa (PSI)	Engine Type and Number of Cylinders
4.9L (300 CID) I-6	4.00 x 3.98	153624	275 (40-60)	O.H.V. I-6

CYLINDER HEAD

Engine	Combustion Chamber Volume C.C.③	Valve Guide Bore Diameter		Valve Seat Width①		Valve Seat Runout TIR Maximum	Valve Arrangement Front to Rear	Gasket Surface Flatness②	Rocker Arm Falcrum Thread Diameter Std.①
		Intake	Exhaust	Intake	Exhaust				
4.9L (300)	65.4-68.4	.3433-.3443	.3433-.3443	.060-.080	.070-.090	.002	E-I-E-I-E-I-E-I-E-I-E-I	.006 in any 6 in. .007 overall	5/16-18

①Valve seat angle — 45°.
②Gasket surface finish — RMS 60-150.
③Compression pressure (PSI) of the lowest cylinder must be at least 75% of the highest to be within specification.

VALVE ROCKER ARM SHAFT, PUSH RODS AND TAPPETS

Engine	Rocker Arm Lift Ratio to 1	Push Rod Runout TIR Maximum	Valve Tappet or Lifter			Collapsed Tappet Gap (Clearance)	
			Standard Diameter	Clearance to Bore①	Hydraulic Lifter Leakdown Rate②	Allowable	Desired
4.9L (300 CID) I-6	1.61	.015	.8740-.8745	.0007-.0027	10 to 50 seconds for 1/16 travel	.100-.200	.125-.175

①Service limit — .005.
②Time required for plunger to leakdown .0625 under load of 50 lbs. using leakdown fluid in tappet.

VALVE SPRINGS

Engine	Valve Spring Compression Pressure Lbs. @ Specified Height		Valve Spring Free Length (Approximate)		Valve Spring Assembled Height②		Valve Spring Out Of Square
	Intake①	Exhaust	Intake	Exhaust	Intake	Exhaust	
4.9L (300 CID) I-6	66-74 @ 1.640 166-184 @ 1.240	66-74 @ 1.470 166-184 @ 1.070	1.96	1.78	1.61-1.67	1.44-1.50	5/64 (.078)

①Service limit — 10% loss of pressure.
②Pad to retainer.

VALVES

Engine	Valve Stem to Guide Clearance①		Valve Head Diameter②		Valve Face Runout TIR Maximum
	Intake	Exhaust	Intake	Exhaust	
4.9L (300 CID) I-6	.0010-.0027	.0010-.0027	1.769-1.793	1.551-1.569	.0020

①Service clearance — .0055 Maximum.
②Valve face angle — 44°.

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VALVES (Continued)

Engine	Valve Stem Diameter					
	Standard		.015 Oversize		.030 Oversize	
	Intake	Exhaust	Intake	Exhaust	Intake	Exhaust
4.9L (300 CID) I-6	.3416-.3423	.3416-.3423	.3566-.3573	.3566-.3573	.3716-.3723	.3716-.3723

CAMSHAFT

Engine	Lobe Lift①		Camshaft End Play		Camshaft Journal To Bearing Clearance②
	Intake	Exhaust	End Play	Service Limit	
4.9L (300 CID) I-6	.249-.247③	.249-.247③	.001-.007	.009	.001-.003

①Maximum allowable lift loss — .005.
②Service clearance — .006.
③F-150 4 x 2 w/2.47:1 or 2.75:1 axle ratio and manual transmission (49S).

CAMSHAFT DRIVE

Engine	Camshaft Journal Diameter — Standard①				Camshaft Bearing Inside Diameter				Camshaft Front Bearing Location②	Assembled Gear Face Runout③	
	No. 1	No. 2	No. 3	No. 4	No. 1	No. 2	No. 3	No. 4		Crankshaft	Camshaft
4.9L (300 CID) I-6	2.017-2.018	2.017-2.018	2.017-2.018	2.017-2.018	2.019-2.020	2.019-2.020	2.019-2.020	2.019-2.020	.020-.035	.005	.005

①Camshaft journal runout — .008 TIR maximum.
②Distance in inches that front edge of the bearing is installed below the front face of the cylinder block.
③Gear backlash — .004-.010.

CYLINDER BLOCK

Engine	Cylinder Bore Diameter①	Main Bearing Bore Diameter②	Distributor Shaft Bearing Bore Diameter	Head Gasket Surface Flatness	Head Gasket Surface Finish	Tappet Bore Diameter
4.9L (300 CID) I-6	4.0000-4.0048	2.5902-2.5910	.5155-.5165	.003 in any 6 in. .006 overall	RMS 60-150	.8752-.8767

①Maximum out-of-round .0015, Service limit — .005, Maximum taper service limit — .010, Cylinder bore surface finish RMS 18-38, Bore taper service limit — .010
②Crankshaft to rear face of block runout. TIR maximum .005.

CRANKSHAFT AND FLYWHEEL

Engine	Main Bearing Journal Diameter①	Main Bearing Journal Runout TIR Maximum②	Main Bearing Thrust Face Runout TIR Maximum	Main Bearing Journal Taper Maximum Per Inch	Thrust Bearing Journal Length	Main and Rod Bearing Journal Finish RMS Maximum	Main Bearing Thrust Face Finish RMS Maximum
4.9L (300 CID) I-6	2.3982-2.3990	.002	.001	.0005	1.1990-1.2010	12	35 Front — 25 Rear

①Maximum out-of-round — .0006.
②Service limit — .005.

CRANKSHAFT AND FLYWHEEL (Continued)

Engine	Connecting Rod Journal Diameter①	Connecting Rod Journal Taper Per Inch Maximum	Crankshaft Free End Play②	Flywheel Clutch Face Runout Assembled	Flywheel Ring Gear Lateral Runout TIR		Flywheel Clutch Face Run-out
					Std. Trans.	Auto. Trans.	
4.9L (300 CID) I-6	2.1228-2.1236	.0006	.004-.008	.010	.040	.060	0.010

①Maximum out-of-round — .0006.
②Service limit — .012.

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CRANKSHAFT BEARINGS

Engine	Connecting Rod Bearing to Crankshaft Clearance Selective Fit			Main Bearing to Crankshaft Clearance Selective Fit		
	Desired	Allowable	Bearing Wall Thickness Std.①	Desired	Allowable	Bearing Wall Thickness Std.①
4.9L (300 CID) I-6	.0008-.0015	.0007-.0024	.0752-.0757	.0008-.0015	.0010-.0028	.0951-.0956

①.For .002 undersize add .001 to standard wall thickness.

CONNECTING ROD

Engine	Piston Pin Bore or Bushing I.D.	Rod Bearing Bore I.D.①	Rod Length Center to Center	Connecting Rod Alignment Maximum Total Difference		Rod to Crankshaft Assembled Side Clearance ③
				Twist②	Bend②	
4.9L (300 CID) I-6	.9734-.9742	2.2750-2.2758	6.2082-6.2112	.024	.012	.006-.013

① Connecting rod bearing bore maximum out-of-round — .0006.
② Pin bushing and crankshaft bore must be parallel and in same vertical plane within specified total difference when measured at the ends of an 8-inch long bar, 4 inches on each side of rod centerline.
③ Service limit — .018.

PISTON

Engine	Diameter ①			Piston to ③ Bore Clearance	Piston Pin Bore Diameter	Ring Groove Width Compression		
	Coded Red	Coded Blue	.003 Oversize	Selective Fit		Top	Bottom	Oil
4.9L (300 CID) I-6 ②	3.9982-3.9988	3.9994-4.0000	4.0008-4.0014	.0010-.0018	.9754-.9757	.080-.081	.080-.081	.188-.189

① Measured at the piston pin bore centerline at 90° to the pin.
② Over 8500 Lbs. GVW.
③ Rebuild specification only.

PISTON PIN

Engine	Length	Diameter			To Piston Pin Bore Clearance ①	To Connecting Rod Bushing Clearance
		Standard	.001 Oversize	.002 Oversize		
4.9L (300 CID) I-6	3.150-3.170	.9749-.9754	.9760-.9763	.9770-.9773	.0002-.0004 ②	Interference Fit

①Selective Fit.
②Under 8500 Lbs. GVW-.0003-.0005.

PISTON RINGS

Engine	Ring Width Compression		Side Clearance Compression ①			Ring Gap Compression		
	Top	Bottom	Top	Bottom	Oil	Top	Bottom	Oil ②
4.9L (300 CID) I-6	.0774-.0781	.0770-.0780	.0019-.0036	.002-.004	Snug	.010-.020	.010-.020	.015-.055

① Service limit — .002 maximum increase in clearance.
② Steel rail.

OIL PUMP AND OIL CAPACITY

Engine	Relief Valve Spring Pressure Lbs. @ Specified Length	Driveshaft to Housing Clearance	Relief Valve to Housing Clearance	Rotor Assembly End Clearance	Outer Race to Housing Clearance	Engine Oil Capacity			Inner ② to Outer Rotor Tip Clearance
						U.S. Quarts	Imperial Quarts	Liters	
4.9L (300 CID) I-6	20.6-22.6 @ 2.49	.0015-.0030	.0015-.0030	.004 Maximum	.001-.013	5	4-2	4-7	.012 Maximum

① Add 1 U.S. quart (or equivalent in Imperial Quarts or Liters) when replacing filter.
② With feeler gauge inserted ½ inch minimum and rotor removed from pump housing.

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TORQUE LIMITS — 4.9L (300 CID) I-6 ENGINE

NOTE: All values are in N•m (ft-lbs) unless otherwise noted. Oil threads with engine oil unless the threads require oil or water-resistant sealer. The standard torque limits listed below are applicable for all functions not listed in the special torque chart.

1/4-20	5/16-18	5/16-24	3/8-16	3/8-24	7/16-14	7/16-20	1/2-13	9/16-18
8-12 (6-9)	17-24 (12-18)	19-27 (14-20)	30-43 (22-32)	37-51 (27-38)	55-75 (40-55)	55-81 (40-60)	75-109 (55-80)	116-162 (85-120)

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PIPE THREADS

1/8-27	1/4-18	3/8-18	1/2-14
7-11 (5-8)	17-24 (12-18)	30-44 (22-33)	34-47 (25-35)

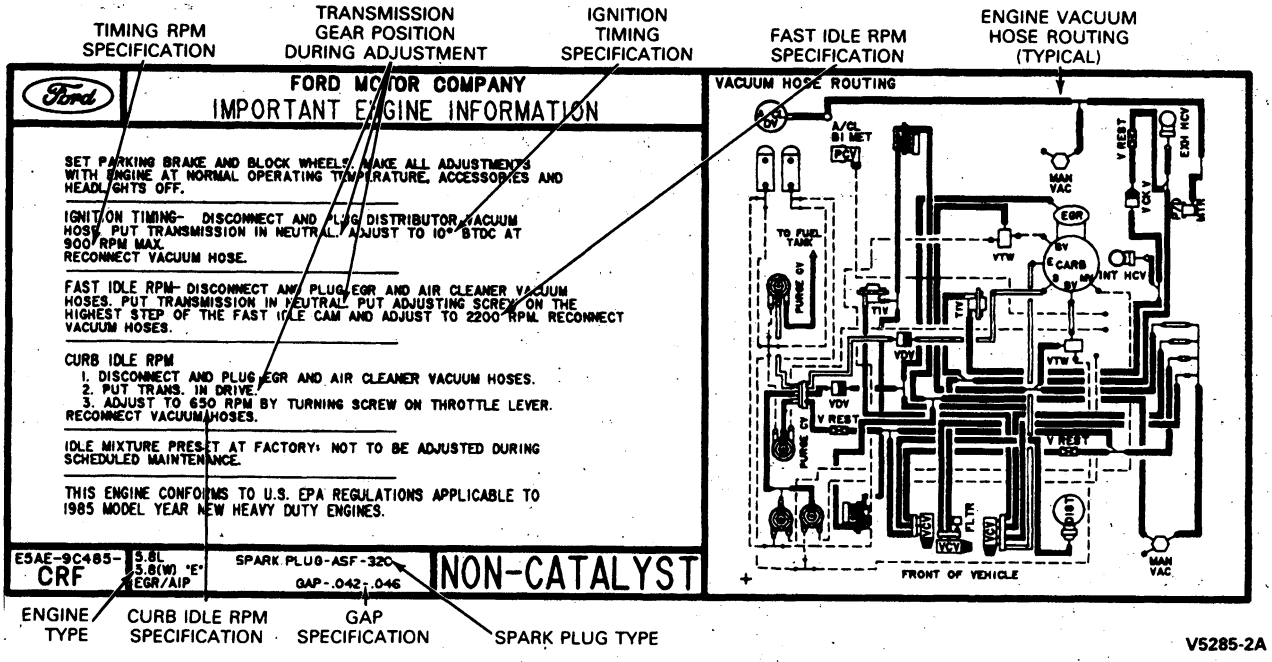
TORQUE SPECIFICATIONS

Item	Torque		Item	Torque	
	N•m	ft-lbs		N•m	ft-lbs
Connecting Rod Nut	55-61	40-45	Water Outlet Housing	17-24	12-18
Cylinder Front Cover	17-24	12-18	Water Pump to Block/Front Cover	17-24	12-18
Cylinder Head Bolts	①	①	Alternator Bracket to Cylinder Block — Bolt	41-61	30-45
Damper to Crankshaft	177-203	130-150	Alternator Adjusting Arm to Cylinder Block Bolt	26-36	19-27
EGR Valve to Carburetor Spacer or Intake Manifold	17-24	12-18	Alternator Adjusting Arm to Alternator Bolt	33-54	24-40
Flywheel to Crankshaft	102-115	75-85	Thermactor Pump Pivot Bolt	41-48	30-35
Main Bearing Cap Bolts	82-94	60-70	Thermactor Pump Adjusting Arm to Pump	30-43	22-32
Manifold to Cylinder Head — Intake②	30-43	22-32	Thermactor Pump Pulley to Pump Hub	17-24	(150-220 in-lbs)
Manifold to Cylinder Head — Exhaust②	30-43	22-32			
Oil Filter Insert to Cylinder Block/Adaptor	20-48	15-35	Thermactor Pump Bracket to Cylinder Block	30-43	22-32
Oil Filter Adaptor to Cylinder Block	55-67	40-50	Fuel Filter to Carburetor/Pump	10-11	(80-100 in-lbs)
Oil Filter to Adaptor or Cylinder Block	1/2 turn after gasket contacts sealing surface — oiled gasket		Carburetor Attaching Nuts	17-20	12-15
			Camshaft Thrust Plate to Cylinder Block	16-24	12-18
			Fuel Pump to Cylinder Block/Front Cover	17-24	12-18
Oil Inlet Tube to Pump	14-20	10-15	Carburetor Mounting Stud	7-13	5-10
Oil Pan Drain Plug	21-33	15-25	Distributor Clampdown	24-33	17-25
Oil Pan to Cylinder Block②	14-17	10-12	Intake Manifold Vacuum Fittings	8-13	6-10
Oil Pump to Cylinder Block	14-20	10-12	Timing Pointer to Front Cover	17-24	12-18
Oil Inlet Tube to Main Bearing Cap	30-43	22-32	Thermactor Air Manifold to Cylinder Head (Nut and Ferrule Assy.)	19-22	14-16
Pulley to Damper Bolt	48-67	35-50	Thermactor Air Check Valve to Thermactor Air Manifold	22-26	16-19
Rocker Arm Bolt	24-31	17-23	Pressure Plate and Cover Assy. to Flywheel	16-25	12-18
Spark Plug to Cylinder Head	14-20	10-15			
Valve Rocker Arm Cover②	7.9-11.9	(70-105 in-lbs)			
Valve Push Rod — Cover to Cylinder Block	2.8-3.9	(25-35 in-lbs)			

① Progressively increase the tightness in three steps using this sequence:
1st step — tighten all bolts to 67-75 N•m (50-55 ft-lb)
2nd step — tighten all bolts to 82-88 N•m (60-65 ft-lb)
3rd step — tighten all bolts to 94-115 N•m (70-85 ft-lb)
② Follow bolt tightening sequence in this section.

CA4970-2E

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V5285-2A

SPECIAL SERVICE TOOLS

Tool Number	Description	Tool Number	Description
T50T-100-A	Impact Slide Hammer	T82T-6256-A	Camshaft Gear Puller
T59L-100-B	Impact Slide Hammer	TOOL-6331-E	Upper Main Bearing Insert Remover & Replacer
T58L-101-B	Puller	T74P-6375-A	Flywheel Holding Tool
D78P-4201-B	Dial Indicator Mag. Base	TOOL-6500-E	Hydraulic Tappet Leakdown Tester
TOOL-4201-C	Dial Indicator With Bracketry	T70P-6513-A	Tappet Bleed Down Wrench
T70P-6000	Engine Lifting Bracket	TOOL-6513-ABA	Valve Holdup Air Adapter
T64L-6011-EA	Cylinder Ridge Reamer	TOOL-6513-DD	Valve/Clutch Spring Tester
T73L-6011-A	Cylinder Hone Set	T79T-6527-B	Rocker Arm Stud Replacer
T61P-6019-B	Front Cover Aligner	T70P-6049-A	Valve Spring Compressor
T68P-6135-A	Piston Pin Remover/Replacer	TOOL-6565-AB	Cup Shaped Adapter
T81P-6135-A	Piston Pin Remover/Replacer Adapters	T73L-6600-A	Pressure Gauge
T65L-6250-A	Camshaft Bearing Set	D79P-6666-A	Spark Plug Boot Puller
T65L-6306-A	Camshaft Gear Replacing Adapter	T74P-6666-A	Spark Plug Wire Remover
T52L-6306-AEE	Crankshaft Damper Replacer	T65P-6701-A	Rear Oil Seal Replacer
D81L-6002-C	Piston Ring Compressor	D79L-6731-A	Oil Filter Wrench
T70P-6B070-B	Front Cover Seal Remover	D79L-6731-B	Oil Filter Wrench
T70P-6B070-A	Front Cover Seal Replacer	T74P-7137-A	Pilot Bearing Replacer
T58P-6316-D	Crankshaft Damper Remover		

CA6539-2F

ROTUNDA TOOLS

Model No.	Description
014-00036	Engine Sling
014-00133	Floor Crane
066-00017	Transmission Jack

CA7331-1E

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SECTION 21-21 5.0L EFI (302 CID) V-8 and 5.8L EFI (351 CID) W-V-8 Engines

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VEHICLE APPLICATION

All Light Truck Models.

DESCRIPTION

WARNING: DO NOT OPERATE THE ENGINE WITH THE HOOD OPEN UNTIL THE FAN HAS BEEN FIRST EXAMINED FOR POSSIBLE CRACKS AND SEPARATION.

Engine

The 5.0L (302 CID) EFI V-8 and 5.8L (351 CID) EFI W-V-8 engines have the same basic design. The cylinder block for these engines is of special high-grade cast iron, thin-wall construction. The crankshaft has five main bearings and is precision-cast nodular iron. Pistons are aluminum alloy, tin plated. Valve rocker arms are individually bolt mounted. The valve tappets are hydraulic.

The 5.0L (302 CID) EFI V-8 is used as an option on some F-150—F-250 and Bronco models also E-150, and E-250. The 5.8L (351 CID) EFI W-V-8 is optional for all models. An aluminum intake manifold is used on 5.0L EFI and 5.8L (351 CID) EFI W-V-8 engines. Refer to the Specification.

Engine Code Information Label

Refer to Figs. 1 and 2.

Located on the rocker arm cover is the engine code information label containing, among other pertinent data, an engine calibration number, an engine build date, an engine plant code and an engine code. Refer to the following figures.

Emission Calibration Label

The emission calibration number label (Fig. 2A) is located on the LH side door or LH door post pillar. It identifies the engine calibration number, the engine code number and revision level.

These numbers are used to determine if parts are unique to specific engines.

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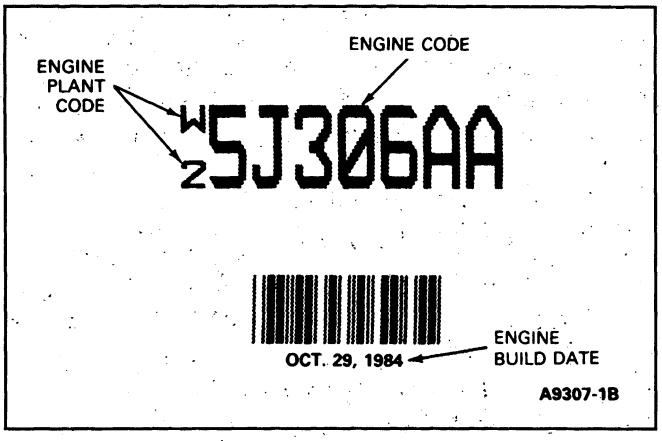


FIG. 1 Engine Information Decal—5.0L—Windsor Engine—Typical

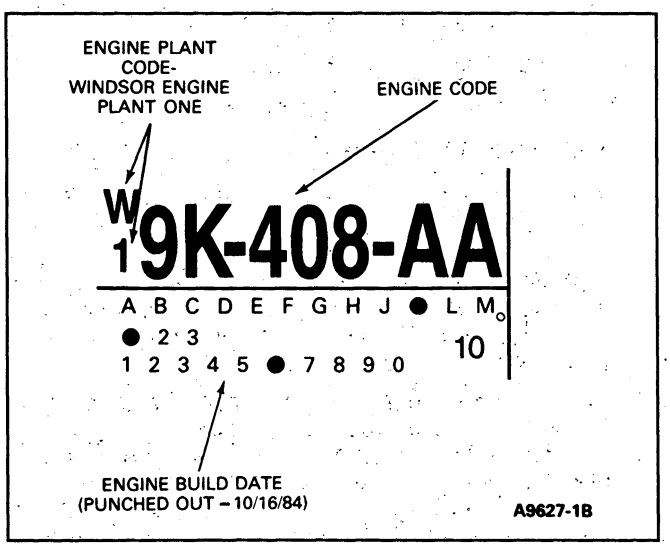


FIG. 2 Engine Information Decal—5.8L Engine

NOTE: It is imperative that the engine codes and the calibration number be used when ordering parts or making inquiries about the engine.

Lubrication System

A typical lubrication system is shown in Figure 3.

Cooling System

A typical cooling system is shown in Figure 4.

Exhaust Emission Control System

The exhaust emission control devices used on these engines are covered in the Emissions Diagnosis* manual.

Crankcase Ventilation System

These engines are equipped with a positive closed-type crankcase ventilation system directing the crankcase vapors to the intake manifold for combustion.

DIAGNOSIS AND TESTING

Refer to Diagnosis and Testing in Section 21-01, General Gasoline Engine Service.

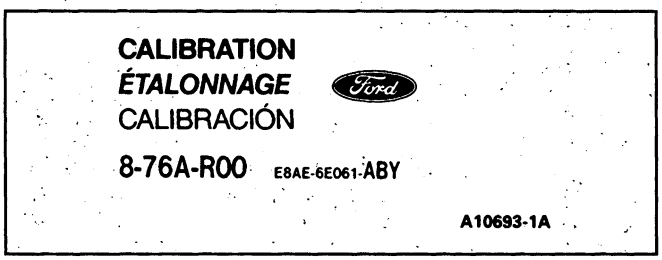


FIG. 2A Emission Calibration Label

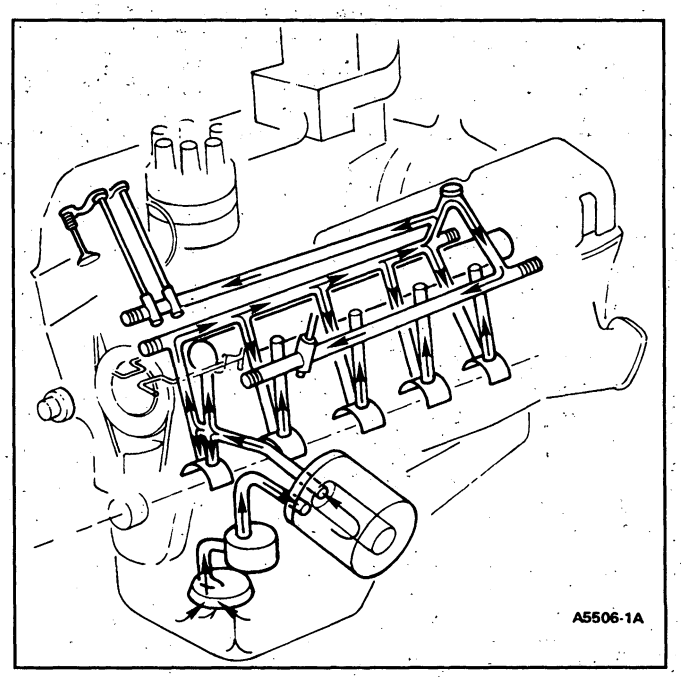


FIG. 3 Typical Lubrication System

ADJUSTMENTS

Valve Clearance

The valve arrangement of the LH bank is E-I-E-I-E-I-E-I and on the RH bank is I-E-I-E-I-E-I-E.

A 1.52mm (0.060 inch) shorter push rod or a 1.52mm (0.060 inch) longer push rod is available for service to provide a means of compensating for dimensional changes in the valve mechanism. Refer to the Master Parts List or the Specifications listed at the end of this Section for the appropriate color code.

Valve stem-to-valve rocker arm clearance should be within specifications with the hydraulic tappet completely collapsed. Repeated valve reconditioning operations (valve and/or valve seat refacing) will decrease the clearance to the point that if it is not compensated for, the hydraulic valve tappet will cease to function and the valve will be held open.

The use of positive stop rocker arm bolts eliminates the need to adjust the valve clearance. However, to obtain the specified valve clearance, it is important that all valve components be in a serviceable condition and installed and tightened properly.

To determine whether a shorter or a longer push rod is necessary, make the following check.

*Can be purchased as a separate item.

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5.0L (302 CID) EFI V-8 Engine

1. Install an auxiliary starter switch. Crank the engine with the ignition switch in OFF position until the No. 1 piston is on TDC after the compression stroke.
2. With the crankshaft in the positions designated in Steps 3, 4 and 5, position the tappet compressor using Tappet Bleed Down Wrench Tool T71P-6513-B or equivalent on the rocker arm (Fig. 5).

   Slowly apply pressure to bleed down the tappet until the plunger is completely bottomed (Fig. 5). Hold the tappet in this position and check the available clearance between the rocker arm and the valve stem tip with a feeler gauge.

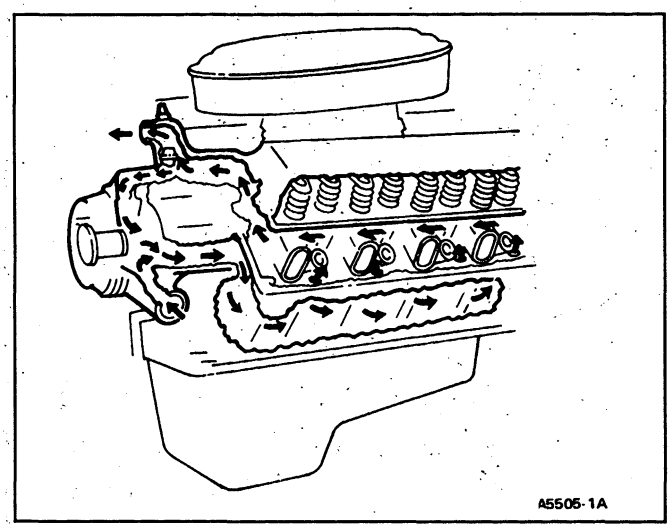


FIG. 4 Typical Cooling System

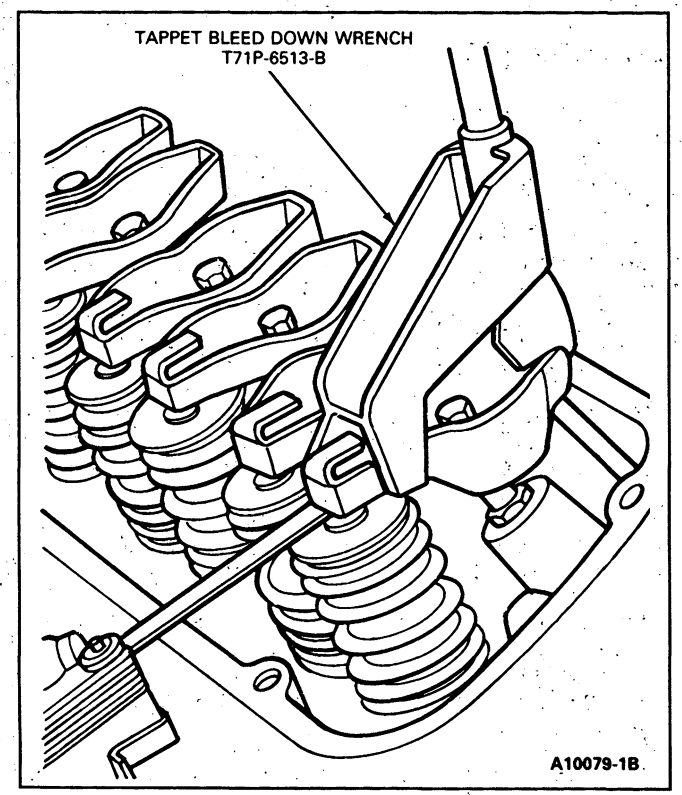


FIG. 5 Checking Valve Clearance—Hydraulic Valve Tappets

   If the clearance is less than specifications, install a shorter push rod. If the clearance is greater than specifications, install a longer push rod.
3. With the No. 1 piston on TDC at the end of the compression stroke, POSITION 1 in Fig. 6, check the following valves:

   No. 1 Intake No. 1 Exhaust

   No. 7 Intake No. 5 Exhaust

   No. 8 Intake No. 4 Exhaust
4. Rotate the crankshaft to POSITION 2 in Fig. 6 and check the following valves.

   No. 5 Intake No. 2 Exhaust

   No. 4 Intake No. 6 Exhaust
5. Rotate the crankshaft to POSITION 3 in Fig. 6 and check the following valves.

   No. 2 Intake No. 7 Exhaust

   No. 3 Intake No. 3 Exhaust

   No. 6 Intake No. 8 Exhaust

5.8L (351 CID) EFI W-V-8 Engine

1. Disconnect the brown lead (I terminal) and the red and blue leads (S terminal) at the starter relay.

   Install an auxiliary starter switch between the battery and S terminals of the starter relay. Crank the engine with the ignition switch in OFF position until the No. 1 piston is on TDC on the compression stroke.
2. With the crankshaft in the positions designated in Steps 3, 4 and 5, position the tappet compressor tool on the rocker arm. Slowly apply pressure to bleed down the tappet until the plunger is completely bottomed (Fig. 5). Hold the tappet in this position and check the available clearance between the rocker arm and the valve stem tip with a feeler gauge.

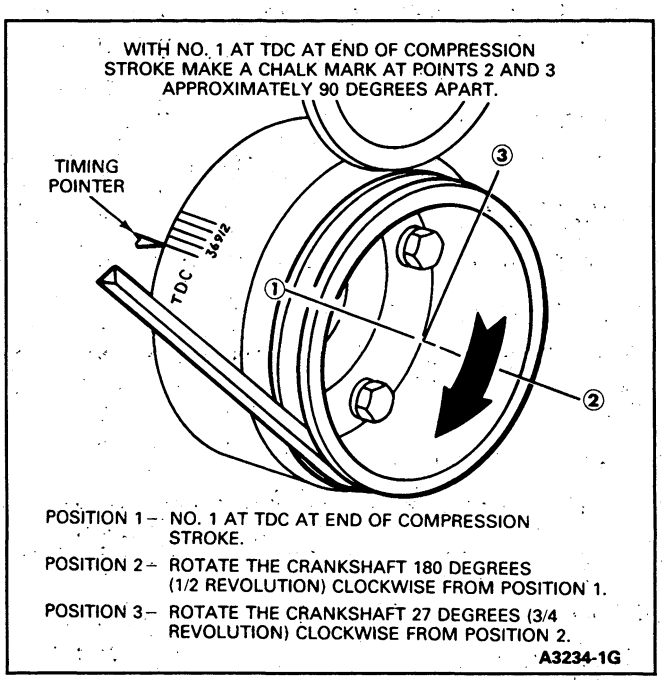


FIG. 6 Position of Crankshaft for Checking and Adjusting Valve Clearance—5.0L EFI Engine

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3. With the No. 1 piston on TDC at the end of the compression stroke, POSITION 1 in Fig. 6, check the following valves:

   No. 1 Intake No. 1 Exhaust

   No. 4 Intake No. 3 Exhaust

   No. 8 Intake No. 7 Exhaust

4. After these valves have been checked, rotate the crankshaft to POSITION 2 in Fig. 6 and check the following valves:

   No. 3 Intake No. 2 Exhaust

   No. 7 Intake No. 6 Exhaust

5. After these valves have been checked, rotate the crankshaft to POSITION 3 in Fig. 6 and check the following valves:

   No. 2 Intake No. 4 Exhaust

   No. 5 Intake No. 5 Exhaust

   No. 6 Intake No. 8 Exhaust

   If the clearance is less than specifications, install a shorter push rod. If the clearance is greater than specifications, install a longer push rod.

REMOVAL AND INSTALLATION

When installing nuts or bolts that must be tightened (refer to torque specifications), oil the threads with lightweight engine oil. **Do not oil threads that require oil-resistant or water-resistant sealer.**

Refer to Section 21-01, General Service for Cleaning, Inspection and Test procedures.

Electronic Fuel Injection

Refer to Section 24-05 for removal and installation of EFI components.

Engine Assembly

The engine removal and installation procedures are for the engine only without the transmission attached.

F-150—F-250—Bronco

Removal

1. Drain the cooling system and the crankcase. Refer to Section 27-02, Cooling System Service. Remove hood. Refer to Section 44-21, Hood and Hinges.
2. Disconnect the battery and ground cables from the cylinder block.
3. On 5.8L EFI remove the air intake duct assembly, including the crankcase ventilation hose and carbon cannister hose. On 5.0L EFI remove the air intake hoses, PCV tube, and carbon canister hose.
4. Disconnect the radiator lower and upper hose at the radiator. If equipped with an automatic transmission, disconnect the transmission oil cooler lines.
5. If so equipped, discharge the A/C system and remove the A/C condenser. Refer to Section 36-61, F-150 through F-350 and Bronco Manual A/C—Heater System. Disconnect A/C lines at the compressor.
6. Remove the fan shroud and position it over the fan. Remove the radiator. Refer to Section 27-04, Radiators. Remove the fan shroud, fan spacer, belts and pulley.
7. Remove the alternator bolts and allow the alternator to swing down and out of the way.
8. Disconnect the oil pressure sending unit wire from the sending unit, and the flexible fuel line at the fuel tank line. Plug the fuel tank line. Disconnect evaporative emission hoses at the evaporative canister. For 5.0L EFI, disconnect chassis fuel line quick disconnects at fuel rails.
9. Disconnect the accelerator cable from the throttle body. Disconnect speed control linkages, if so equipped. Disconnect the transmission kickdown rod and remove the retracting spring, if so equipped. Disconnect power brake booster vacuum hose, if so equipped. For 5.0L EFI, after disconnecting accelerator and transmission T.V. cable from throttle body, disconnect throttle bracket from upper intake manifold and swing out of the way with cables still attached to bracket.
10. Disconnect the heater hoses from the water pump and intake manifold, or at tee for 5.0L EFI. Disconnect the water temperature sending unit wire from the sending unit.
11. Remove the flywheel housing-to-engine upper bolts.
12. Disconnect the engine wire loom and position out of the way. Disconnect the ground strap from the cylinder block.
13. Raise the front of the vehicle. Disconnect the starter cable from the starter. Remove the starter. Refer to Section 28-02, Positive Engagement Starter.
14. Disconnect the muffler inlet pipes and exhaust heat control valve, if so equipped, from the exhaust manifolds. Disconnect the engine support insulators from the brackets on the frame underbody (Fig. 7).

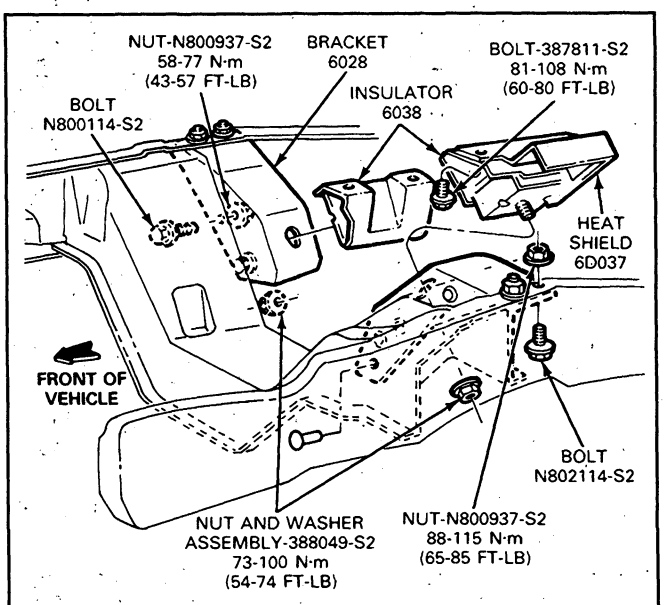


FIG. 7 Engine Front Supports—F-150—F-350 and Bronco

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On a vehicle with automatic transmission, remove the converter inspection plate. Remove the torque converter-to-flywheel attaching bolts.

Remove the remaining flywheel housing-to-engine bolts.

15. If so equipped, disconnect A/C compressor magnetic clutch lead wire. Refer to Section 36-61, F-150—F-350 and Bronco Manual Air Conditioning—Heater System.
16. Lower the vehicle, and support the transmission. Install Engine Lifting Bracket Tool T70P-6000 or equivalent on the intake manifold lifting eyes (5.8L-W EFI). Then, attach the engine lifting sling (attach to engine mounted lifting eyes for 5.0L EFI).
17. Raise the engine slightly and carefully pull it from the transmission. Carefully lift the engine out of the engine compartment so that the rear cover plate is not bent or other components damaged. Install the engine on a work stand.

Installation

1. Attach the engine lifting brackets and sling. Remove the engine from the workstand.
2. Lower the engine carefully into the engine compartment. Make sure the dowels in the block are through the rear cover plate, then engage the holes in the flywheel housing.

   On a vehicle with manual transmission, start the transmission main drive shaft into the clutch disc. It may be necessary to adjust the position of the transmission in relation to the engine if the input shaft will not enter the clutch disc. **If the engine hangs up after the shaft enters, turn the crankshaft slowly (transmission in gear) until the shaft splines mesh with the clutch disc splines.**
3. Install the flywheel housing upper bolts.
4. Install the engine support insulator-to-bracket washers and attaching nuts. Disconnect the engine lifting sling and remove the lifting eyes (5.8L-W EFI). 5.0L EFI lifting eyes remain with engine.
5. Raise the front of the vehicle. Connect both exhaust manifolds and exhaust heat control valve, if so equipped, to the muffler inlet pipes. Tighten the nuts to specifications. Refer to Section 26-01, Exhaust Systems Service.
6. Position and install the starter and the starter cable. Refer to Section 28-02, Positive Engagement Starter.
7. Install the remaining flywheel housing-to-engine bolts.
8. On a vehicle with automatic transmission, install the converter-to-flywheel attaching bolts. Install the converter inspection plate.
9. Remove the support from the transmission and lower the vehicle.
10. If so equipped, connect the A/C compressor magnetic clutch lead wire. Refer to Section 36-61, F-150—F-350 and Bronco Manual Air Conditioning—Heater System.
11. Connect the engine wire loom.
12. Connect the water temperature sending unit wire.
13. Connect the bellcrank/linkage bracket to the intake manifold. Connect the transmission shift rod or cable, if so equipped, as outlined. Install the retracting spring. Connect the accelerator rod and speed control linkage, if so equipped.
14. Remove the plug from the fuel tank line and connect the fuel line and the oil pressure sending unit wire. Reconnect evaporative emission hoses at the evaporative canister. For 5.0L EFI, reconnect chassis fuel lines to fuel rails.
15. Install the pulley, belt, spacer and fan. Position the fan shroud over the fan.
16. Position the alternator and install the alternator bolts. Connect the battery ground cable. Adjust the belt tension to specification. Refer to Section 27-06, Accessory Drive Belt Service.
17. If so equipped, connect two A/C lines to the A/C compressor. Refer to Section 36-61, F-150—F-350 and Bronco Manual Air Conditioning—Heater System.
18. Install the radiator. Refer to Section 27-04 Radiators. Connect the radiator upper and lower hoses. Connect the transmission oil cooler lines, if so equipped. Install the fan shroud.
19. If so equipped, install the A/C condenser to the radiator. Refer to Section 36-61, F-150—F-350 and Bronco Manual Air Conditioning—Heater System Section.
20. Connect the heater hoses at the water pump and intake manifold. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service. Fill the crankcase with the proper grade and quantity of oil. Connect the power brake booster vacuum hose, if so equipped.
21. Operate the engine at fast idle and check all gaskets and hose connections for leaks.
22. Install the air cleaner and intake duct assembly including the crankcase ventilation hose and carbon cannister hose.
23. Evacuate and charge the A/C system, if so equipped. Refer to Section 36-30, Air Conditioning General Service.
24. Install hood. Refer to Section 44-21, Hood and Hinges.

E-150—E-350

Electronic Fuel Injection

Refer to Section 24-05 for removal and installation of EFI components.

Removal

1. Remove engine cover, open the hood, disconnect battery and drain cooling system. Refer to Section 27-02, Cooling System Service. Remove grille assembly including gravel deflector. Remove air cleaner, air ducts and closure hose (5.0L).
2. Remove the upper grille support bracket, hood lock support and condenser upper mounting brackets, if so equipped.
3. If so equipped, discharge the A/C system, and remove the A/C condenser. Refer to Section 36-65, E-150—E-350 Air Conditioning System. Disconnect the A/C lines at the compressor, and remove the accelerator cable bracket. Disconnect

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the speed control linkage, if so equipped. Disconnect the two heater hoses from the engine.

4. Disconnect the radiator hoses at the radiator. Disconnect the heater hoses at the heater core and the water valve.
5. If equipped with an automatic transmission, disconnect the oil cooler lines at the radiator.
6. Remove the fan shroud and fan assembly. Remove the radiator from the vehicle. Refer to Section 27-04, Radiators. Disconnect the alternator lead wires at the alternator.
7. Remove the air cleaner assembly.
8. Disconnect the throttle linkage at the throttle body and remove the accelerator cable bracket from the engine. Disconnect the transmission shift rod, if so equipped.
9. Raise the vehicle on a hoist, drain the crankcase and remove the oil filter.
10. Disconnect the muffler inlet pipes and exhaust heat control valve, if so equipped, at the exhaust manifolds. Remove two bolts retaining the transmission filler tube bracket to the RH cylinder head.
11. Remove the engine mount attaching bolts and nuts (Fig. 8). Remove the starter motor and disconnect the cable. On vehicles equipped with a manual transmission, remove the housing-to-engine bolts. On vehicles equipped with an automatic transmission, remove the converter inspection cover bolts.
12. Remove four nuts attaching the converter to the flex plate.
13. Remove three bolts retaining the adapter plate to the converter housing.
14. Remove four converter housing-to-cylinder block lower bolts. Remove the bolt retaining the ground cable to the cylinder block. Lower the vehicle and support the transmission.

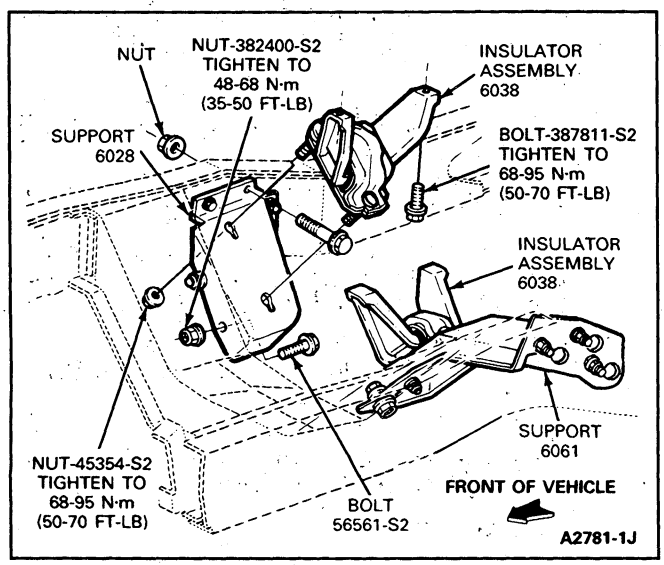


FIG. 8 Engine Front Supports—E-150—E-250 with 5.0L (302 CID) V-8 and E-150—E-350 with 5.8L EFI (351 CID) W-V-8

15. If so equipped, loosen the power steering pump bracket and remove the drive belt. Remove the power steering front bracket bolts.
16. Disconnect the engine wire loom and position it out of the way.
17. If so equipped, disconnect the A/C compressor magnetic clutch lead wire. Refer to Section 36-65, E-150—E-350 Air Conditioning System. Install Engine Lifting Plate Tool T75T-6000-A or equivalent to the intake manifold (attaching bolts). Remove two converter housing-to-cylinder block upper bolts.
18. Position a floor jack under the transmission for support. Position a floor crane to the vehicle and connect it to the lifting bracket. Use engine mounted lifting eyes. Carefully move engine forward in the engine compartment so that no components are damaged.
19. Remove the engine from the vehicle.
20. Install engine on a work stand.

Installation

1. On vehicles equipped with an automatic transmission, connect the floor crane to the engine. Raise the engine and position it into the vehicle aligning the transmission converter to the flywheel (or flex plate) and the engine dowels to the transmission. Lower the engine to the chassis brackets, and align the through-bolt holes on the engine supports (Fig. 8).

   On vehicles equipped with a manual transmission, start the transmission main clutch drive shaft into the clutch disc.

   It may be necessary to adjust the position of the transmission in relation to the engine if the input shaft will not enter the clutch disc. If the engine hangs up after the shaft enters, turn the crankshaft slowly (transmission in gear) until the shaft splines mesh with the clutch disc splines.

   Align the housing on the engine and insert the housing-to-engine bolts. Tighten bolts to 55-67 N·m (40-50 ft-lb).
2. On vehicles equipped with an automatic transmission, install two converter housing-to-cylinder block lower bolts. Remove the lifting bracket from the intake manifold.
3. Remove floor jack from under the transmission, and position it out of the way.
4. If so equipped, connect the A/C compressor magnetic clutch lead wire. Refer to Section 36-65, E-150—E-350 Air Conditioning System.
5. Position the accelerator cable mounting bracket and install three attaching bolts.
6. Position the engine wire harness in retainers and connect at respective locations. Connect vacuum lines at the center of the upper intake manifold. Connect the power brake booster vacuum hose, if so equipped.
7. Connect two heater hoses: one at the heater core and one at the water valve. If so equipped, position the power steering front face bracket and the power steering pump to the water pump and the LH cylinder head. Install the attaching bolts.

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8. Install the fan assembly and spacer to the water pump shaft and position the shroud over the fan assembly.
9. Raise the vehicle on a hoist. Install one bolt attaching ground cable to cylinder block (on vehicles equipped with an automatic transmission, four lower converter housing-to-cylinder block bolts). Install the three adapter plate-to-converter housing bolts. Install four nuts retaining the converter to the flex plate. Install the converter inspection cover and retaining bolts. On vehicles equipped with a manual transmission, start the transmission main drive shaft into the clutch disc. It may be necessary to adjust the position of the transmission in relation to the engine if the input shaft will not enter the clutch disc. **If the engine hangs up after the shaft enters, turn the crankshaft slowly (transmission in gear) until the shaft splines mesh with the clutch disc splines.**
10. Install the starter motor and connect the cable. Install the engine mount attaching bolts and nuts. Tighten to 68-95 N·m (50-70 ft-lb).
11. Install the two bolts that retain the transmission filler tube bracket to the RH cylinder head.
12. Connect the muffler inlet pipes and exhaust heat control valve, if so equipped, at the exhaust manifolds. Refer to torque specifications in Section 26-01, Exhaust System Service. Install the oil filter.
13. Connect the throttle and transmission linkage and the speed control linkage, if so equipped, at the throttle body. Connect the alternator lead wires to the alternator.
14. Position the power steering pump drive belt to its respective pulleys and adjust belt tension. Refer to Section 27-06, Accessory Drive Belt Service. Tighten adjusting bolt to 33-54 N·m (20-40 ft lb), and the pivot bolt to 55-67 N·m (40-50 ft lb). If so equipped, connect two A/C lines at the A/C compressor. Refer to Section 36-65, E-150—E-350 Air Conditioning System. Install the accelerator cable bracket to the dash.
15. Position the radiator to the radiator support and secure with four attaching bolts. Refer to Section 27-04, Radiators. Install the shroud and secure with four attaching bolts.
16. Connect two oil cooler lines at the radiator, if so equipped.
17. Connect the radiator hoses at the radiator.
18. Install the A/C condenser to radiator support, if so equipped. Refer to Section 36-65, E-150—E-350 Air Conditioning System. Install the grille upper support bracket, hood lock support and condenser upper mounting brackets.
19. Install the grille assembly. Fill the crankcase. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service. Install air cleaner, air ducts and closure hose (5.0L).
20. Connect battery, start engine and check for leaks. Adjust idle speed and mixture to specifications on engine decal.
21. Evacuate and charge the A/C system, if so equipped. Refer to Section 36-30, Air Conditioning General Service. Install the air cleaner assembly.
22. Install the engine cover.

Engine Front Supports

The front supports are located on each side of the cylinder block. The procedures given apply to either a RH or LH installation. However, a sheet metal shield on the LH side only is used on F-Series trucks.

F-150—F-350 and Bronco

Removal

1. Remove the bolts attaching the fan shroud to the radiator and position the shroud over the fan.
2. Remove the nut and washer attaching the support insulator to the chassis bracket.
3. Raise the engine.
4. Remove the bolts and lock washers attaching the support insulator to the cylinder block (Fig. 7) and remove the insulator and heat shield (LH side only).

Installation

1. Position the support insulator and heat shield (LH side only) to the cylinder block and install the attaching bolts and lock washers loosely.
2. Carefully lower the engine, guiding the support insulator stud into the support bracket (Fig. 7). Tighten the insulator-to-engine bolts to 68-94 N·m (50-70 ft-lb).
3. Install the insulator-to-chassis bracket nut and washer. Tighten the nut to 88-115 N·m (65-85 ft-lb).
4. Install the fan shroud attaching bolts.

E-150—E-250

Removal

1. Remove fan shroud bolts. Remove the insulator-to-support nuts (Fig. 8).
2. Position transmission jack under engine assembly. Lift engine assembly and then remove starter. Refer to Section 28-02, Positive Engagement Starter.
3. Remove insulator-to-engine bolts and alternator splash shield. Remove the insulators (Fig. 8).

Installation

1. Clear slots in engine block of debris using a 7/16-14 bottoming tap.
2. Install insulators to engine using **new** bolts. Tighten to 68-95 N·m (50-70 ft-lb) (Fig. 8).
3. Install starter. Refer to Section 28-02, Positive Engagement Starter. Then, lower the engine assembly. Move transmission jack out of the way.
4. Replace the insulator-to-support nuts and tighten to 68-95 (50-70 ft-lb). Install fan shroud and bolts.

Engine Rear Supports

The procedures apply to F-150—F-350 and Bronco and E-150—E-350 center mount (Figs. 9 and 10).

F-150—F-350/Bronco

Removal

1. Remove the support insulator-to-crossmember attaching nuts (Fig. 9).

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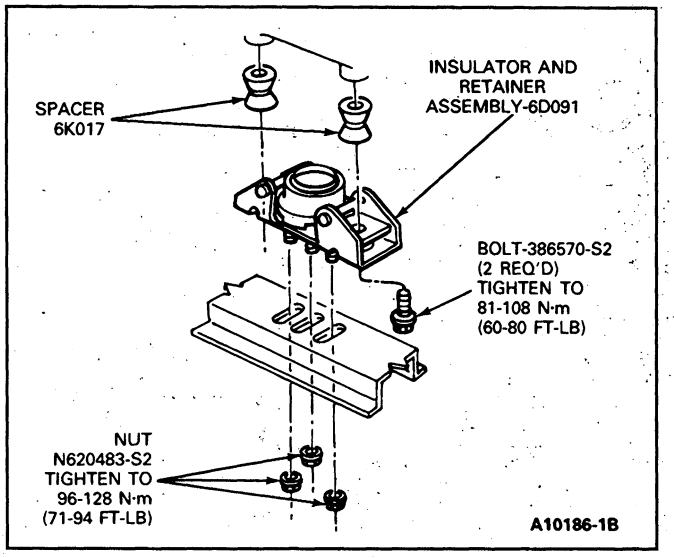


FIG. 9 Engine Rear Support—Bronco

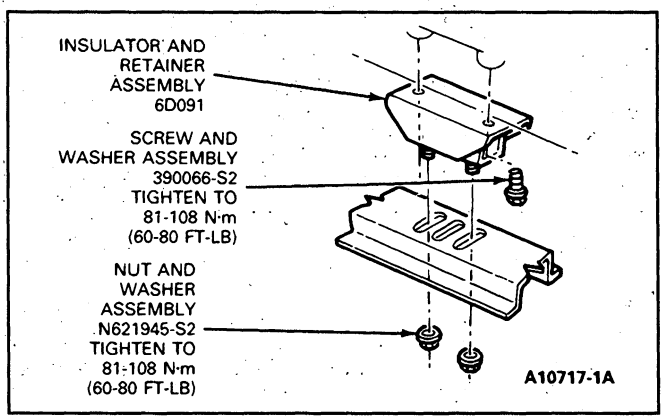


FIG. 10 Engine Rear Support—F-150—F-350

2. Raise the transmission with a floor jack to provide clearance and remove the two bolts, insulator and spacers.

Installation

1. Position the support insulator and spacers (Fig. 10).
2. Install the support insulator-to-transmission extension housing bolts. Tighten the bolts to 81-108 N·m (60-80 ft-lb). Lower the transmission.
3. Install the support insulator-to-crossmember attaching nuts. Tighten the nuts to 68-94 N·m (50-70 ft-lb).

E-150—E-350

Removal

CAUTION: On 138 inch wheel base vehicles. First remove the fuel reservoir to eliminate any part damage due to removal of rear transmission support crossmember. Refer to Section 24, Fuel Tanks and Line and Fuel Evaporative Emission Control System.

1. Raise the vehicle on a hoist.
2. Remove the insulator support nuts securing the rear insulator support to the frame crossmember (Fig. 11).
3. Raise the transmission with Transmission Jack, Rotunda 066-00017 or equivalent, so that the insulator support clears the frame.
4. Remove the insulator support bolts securing the rear insulator support to the transmission, then remove the insulator.

Installation

1. Position the insulator support, then install the bolts securing the insulator support to the transmission (Fig. 11). Tighten the bolts to 68-94 N·m (50-70 ft-lb).
2. Lower the jack supporting the transmission and align the insulator support bolt holes with the holes in the frame assembly.
3. Install the bolts and nuts securing the insulator support to the frame. Tighten to 68-94 N·m (50-70 ft-lb).
4. Lower the vehicle.

Engine Components

Figs. 12 and 13 are typical and provide a reference for procedures. The numbers and part descriptions shown in the key are basic part numbers corresponding with the Ford Master Parts Catalog.

Crankcase Ventilation System

The crankcase ventilation system components for the various applications are shown in Fig. 12. **Any modification of the system prior to the first sale and registration of the vehicle is subject to Federal (U.S.A.) law and to the penalties under the laws of some states thereafter.**

Non-A/C and Non-Super Cooling

Removal

1. Disconnect crankcase vent hose from LH rocker cover fill tube nipple.
2. Remove the air cleaner and intake duct assembly.
3. Disconnect the crankcase vent tube from the rear of upper intake manifold.

Installation

1. Install the air cleaner and intake duct assembly.
2. Insert the elbow into the grommet in the oil filler cap. Connect the crankcase vent rear hose to the elbow and the air cleaner.
3. Start the engine and check for leaks.

A/C and Super Cooling

Removal

1. Disconnect the crankcase vent front hose from the air cleaner.
2. Remove the air cleaner and intake duct assembly. If so equipped, disconnect the oil filler pipe hose from the LH rocker arm cover.
3. Disconnect the crankcase vent rear hose from the rear of the upper intake manifold.

Installation

1. Install the air cleaner and intake duct assembly. If so equipped, connect the oil filler pipe hose to the LH rocker arm cover.

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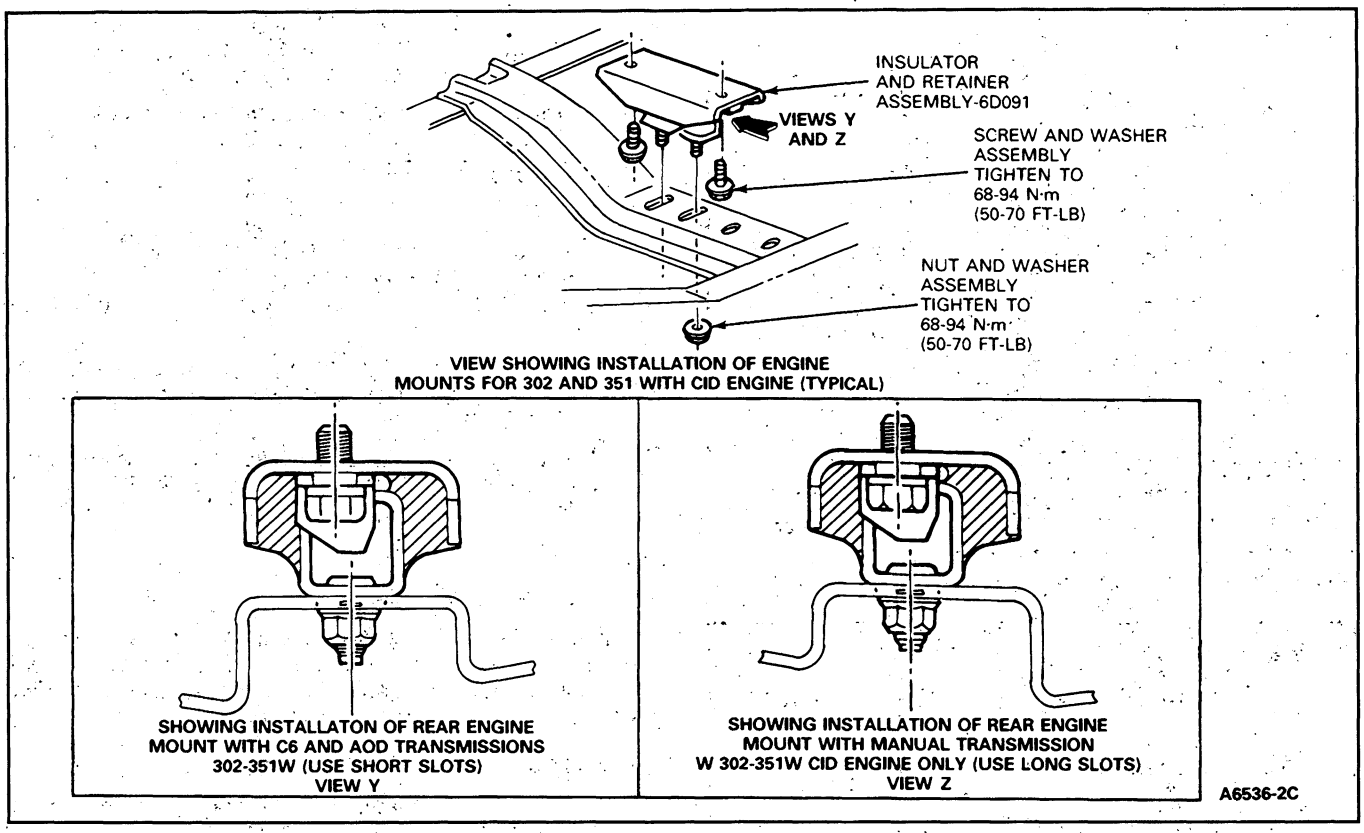


FIG. 11 Engine Rear Support—E-150—E-350

2. Connect the crankcase vent front hose to the air cleaner and the oil filler tube.
3. Start the engine and check for leaks.

Valve Rocker Arm Cover and Rocker Arm

Removal

1. Remove air cleaner and intake duct assembly, including the closed crankcase ventilation hoses and tubes, remove coil and solenoid brackets. For removal of RH rocker cover, remove lifting eye and Thermactor tube.
2. Remove oil filler pipe hose from LH rocker arm cover, if so equipped.
3. Disconnect the spark plug wires from the spark plugs by grasping, twisting and pulling the moulded cap using Spark Plug Wire Remover T74P-6666-A or equivalent (Fig. 15). Remove wires and bracket assemblies from the rocker arm cover attaching stud and position out of the way.
4. Remove vacuum harness and electrical connectors to the vacuum solenoids mounted on the rocker arm covers, if so equipped, and position out of the way.
5. Disconnect evaporative system hoses from the canister or the chassis, if so equipped, and position out of the way.
6. Remove Thermactor air supply hose, if so equipped.
7. Remove rocker arm cover bolts and remove rocker arm covers.
8. Remove the valve rocker arm bolt, fulcrum seat and rocker arm (Fig. 16).

Installation

1. Apply Multi-Purpose Grease D0AZ-19584-AA or equivalent to the top of the valve stem, the fulcrum seat and socket.
2. Install the fulcrum guide, valve rocker arm, fulcrum seat and bolt. Tighten to 25-32 N·m (18-25 ft-lb).
3. Clean and inspect gasket surfaces. Inspect the gasket sealing surface from damage and distortion due to overtightening of the bolts. Repair and straighten as required. Place the new gaskets in the covers, making sure that the tabs of the gasket engage the notches provided in the cover.
4. Position the cover(s) on the cylinder head(s). Install the cover bolts and tighten to 13.6-17.6 N·m (10-13 ft-lbs). Wait two minutes, then tighten bolts again to same specification.
5. Retighten all intake manifold bolts to 32-33 N·m (23-25 ft-lb) using sequence shown in Fig. 20. Install vacuum harness bracket and attaching nut. Tighten to 17-24 N·m (12-18 ft-lb).
6. Reconnect vacuum harnesses and electrical connectors to the vacuum solenoids on the arm covers, if so equipped.
7. Connect spark plug wires and bracket assembly to attaching stud on rocker arm cover and connect wires at spark plugs.
8. Connect thermactor air supply hose, if so equipped.
9. Connect oil filler pipe hose to LH rocker arm, if so equipped.
10. Install the closed crankcase ventilation hoses or tubes.

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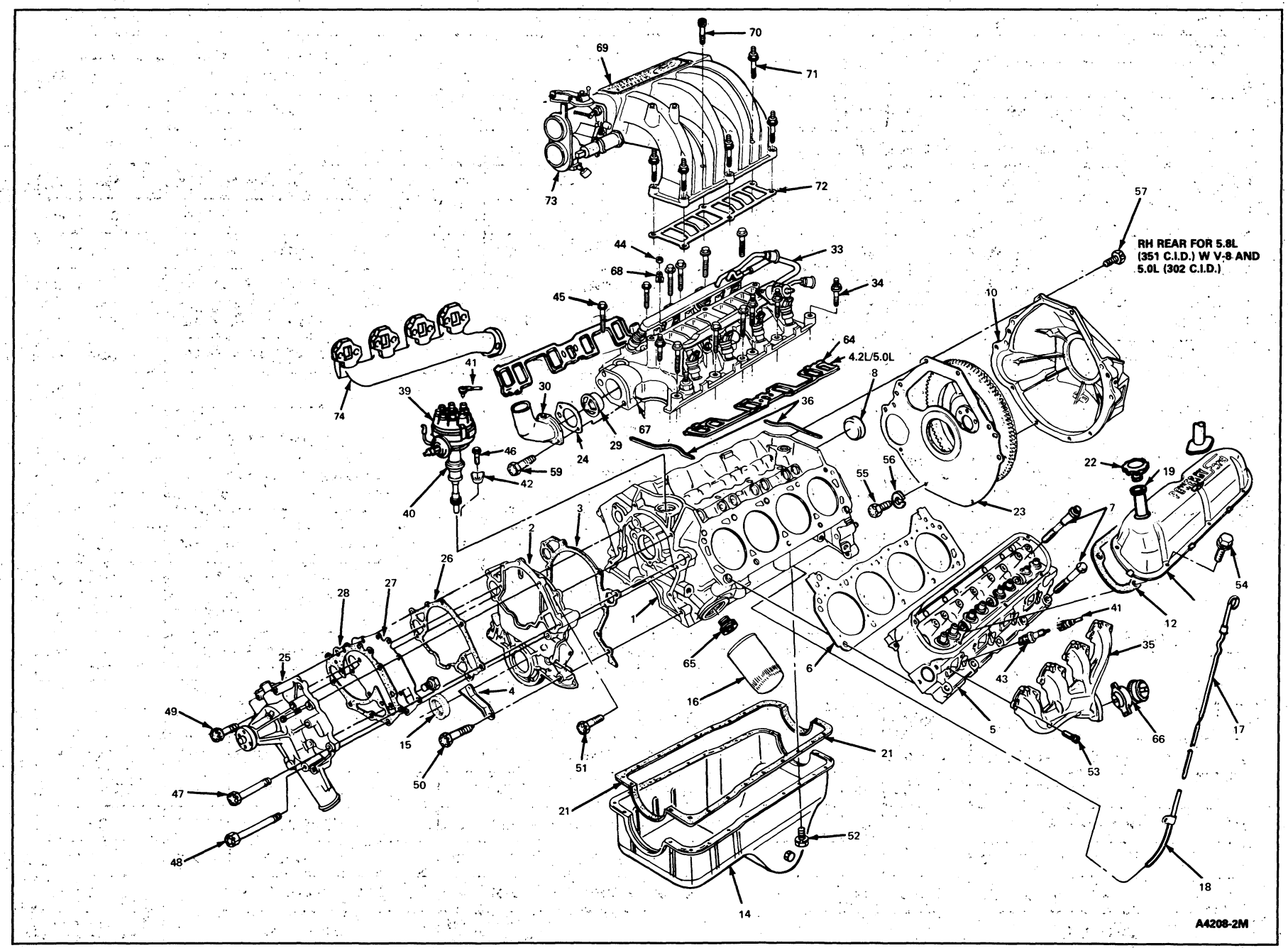


FIG. 12 External Exploded View—5.0L (302 CID) EFI

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REF. NO.	BASIC PART NO.	DESCRIPTION	REF. NO.	BASIC PART NO.	DESCRIPTION	REF. NO.	BASIC PART NO.	DESCRIPTION
1	6009	Cylinder Assy. — (Includes internal parts)	24	8255	Gasket — Water Outlet Connection	49	389083	Bolt — 5/16-18 x 2.70"
2	6059	Cover Assy. — Cylinder Front	25	8501	Pump Assy. — Water	50	56126-S	Bolt — 5/16-18 x 2"
3	6020	Gasket — Cylinder Front Cover	26	8507	Gasket — Water Pump Housing	51	376255	Bolt or Screw — 5/16-18 x 1"
4	6M025	Pointer — Timing	27	8508	Cover — Water Pump	52	373564-S	Bolt — 5/16-18 x 1-7/8"
5	6049	Head — Cylinder	28	8513	Gasket — Water Pump Cover	53	381731-S	Bolt — 3/8-16 x 1-7/8"
6	6051	Gasket — Cylinder Head	29	8575	Thermostat — Water	54	356748-S	Bolt — 1/4-20 x 5/8"
7	6065	Bolt — Cylinder Head	30	8592	Connection — Water Outlet	55	20346-S	Bolt — 5/16-18 x 3/4 — 17-24 N·m (12-18 FT-LBS)
8	6266	Plug — Camshaft Rear Bearing	31		Not Used	56	34806-S	Washer — Lock — 5/16 x 19/32 x 5/64"
9	6375	Flywheel Assy.	32		Not Used	57	20508-S	Bolt — 7/16-14 x 1-3/4"
10	6392	Housing Assy. — Flywheel	33	9F792	Rail Assy. — Fuel	58	34808-S	Washer — Lock — 7/16"
11	6582	Cover Assy. — Valve Rocker Arm (RH)	34		Stud	59		Bolt — 5/16-18
	6A513	Cover Assy. — Valve Rocker Arm (LH)	35	9431	Manifold — Exhaust (LH)	62	6750	Indicator — Oil Level
12	6584	Gasket — Valve Rocker Arm Cover	36	9433	Gasket Set — Manifold	63	6754	Tube Assy. — Oil Level Indicator
13	6853	Hose — Positive Crankcase Ventilation (P.C.V.)	37		Gasket — Upper to Lower Intake Manifolds	64	9439	Gasket Intake Manifold
14	6675	Pan Assy. — Oil	39	12106	Distributor — Cap	65	6890	Insert — Oil Fill Adaptor
15	6700	Seal — Cylinder Front Cover	40	12127	Distributor Assy.	67	9K461	Lower Intake Manifold Assy.
16	6714	Element Assy. — Oil Filter	41	12259	Wire Set — Spark Plug	68		Clip
17	6750	Indicator — Oil Level	42	12270	Clamp — Distributor	69	9425	Upper Intake Manifold
18	6784	Tube Assy. — Oil Level Indicator	43	12405	Spark Plug Assy.	70		Screw
19	6763	Fill Pipe, Oil	44		Nut	71		Stud
20	6853	Tube — Positive Crankcase Ventilation	45		Bolt	72		Gasket
21	6710	Gasket Set — Oil pan	46	20386-S	Bolt — 5/16-18 x 1"	73	9E926	Throttle Body
22	6766	Cap Assy. — Oil Filler	47	388433	Bolt — 5/16-18 x 5.40"	74	9430	Manifold — Exhaust (RH)
23	7007	Plate Assy. — Engine Rear	48	388434	Bolt — 5/16-18 x 6.60"			

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FIG. 12A External Exploded View—Key

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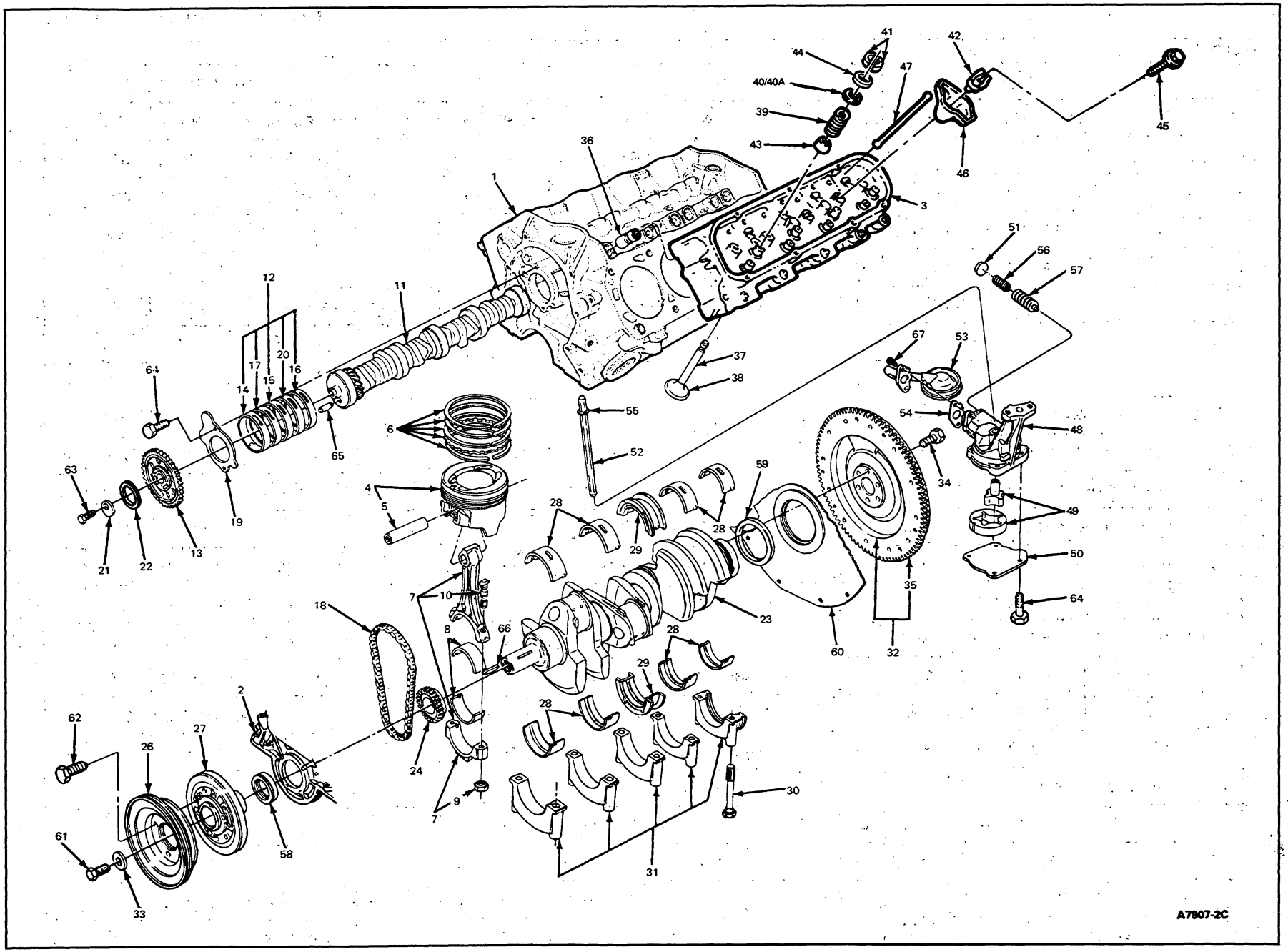


FIG. 13 Internal Exploded View—5.8L (351 CID) EFI W-V-8 Engines

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Ref. No.	Basic Part No.	Description	Ref. No.	Basic Part No.	Description	Ref. No.	Basic Part No.	Description
1	6010	Block Assy. (Internal parts not included)	24	6306	Sprocket — Crankshaft	46	6564	Arm — Valve Rocker
2	6019	Cover Assy. — Cylinder Front	26	6A312	Pulley Assy. — Crankshaft Outer	47	6565	Rod — Valve Push
3	6049	Head — Cylinder	27	6316	Damper Assy. — Crankshaft	48	6600	Pump Assy. — Oil
4	6108	Piston Assy.	28	6333	Bearing — Crankshaft Main (except center)	49	6608	Rotor and Shaft Assy. — Oil Pump Drive
5	6135	Pin — Piston	29	6337	Bearing — Crankshaft Main (center)	50	6616	Plate — Oil Pump Body
6	6148	Ring Set — Piston	30	6345	Bolt — Crankshaft Main Bearing Cap	51	6A616	Plug — Oil Pump Relief Valve
7	6200	Rod Assy. — Connecting	31	*	Main Bearing Cap — Supplied in 6010 Block Assy.	52	6A618	Shaft Assy. — Oil Pump Intermediate
8	6211	Bearing — Connecting Rod	32	6375	Flywheel Assy.	53	6622	Screen, Tube and Cover Assy. — Oil Pump
9	6212	Nut — Connecting Rod	33	6378	Washer — Crankshaft Pulley Retaining	54	6625	Gasket — Oil Pump Inlet Tube
10	6214	Bolt — Connecting Rod	34	6379	Bolt — Flywheel to Crankshaft	55	6629	Ring — Oil Pump Intermediate Shaft
11	6250	Camshaft	35	6384	Gear — Flywheel Ring	56	6670	Spring — Oil Pump Relief Valve
12	6251	Bearing Kit — Camshaft — Standard	36	6500	Tappet Assy. — Hydraulic	57	6674	Plunger — Oil Pump Relief Valve
13	6256	Sprocket — Camshaft	37	6505	Valve — Exhaust	58	6700	Seal — Cylinder Front Cover Oil
14	6261	Bearing — Camshaft Front	38	6507	Valve — Intake	59	6701	Seal — Crankshaft Rear
15	6262	Bearing — Camshaft Center	39	6513	Spring — Valve	60	6A372	Plate — Engine Rear
16	6263	Bearing — Camshaft Rear	40	6514	Retainer — Valve Spring (Intake)	61	377850-S	Bolt — 5/8-18 x 2"
17	6267	Bearing — Camshaft Front Intermediate	40A	6A516	Retainer — Valve Spring (Exhaust)	62	42998-S	Bolt — 3/8-16 x 1"
18	6268	Chain — Timing	41	6518	Key — Valve Spring Retainer	63	43002-S	Bolt — 3/8-16 x 1-1/2"
19	6269	Plate — Camshaft Thrust	42	6A528-A	Fulcrum	64	42911-S	Bolt — 1/4-20 x 5/8"
20	6270	Bearing — Camshaft Rear Intermediate	43	6A517	Valve Stem Seal	65	378189-S	Pin — Dowel — 5/16 x 1-3/8"
21	6278	Washer — Camshaft Sprocket	44	6517	Sleeve — Intake Only	66	372854-S	Key — Woodruff — 1-3/4 x 7/32 x 3/16"
22	6287	Eccentric — Camshaft Fuel Pump	45	6A527-A	Bolt — Rocker Arm Attach	67	357235-S	Bolt — 5/16-18 x 7/8"
23	6300	Crankshaft Assy.						

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FIG. 13A Internal Exploded View—Key

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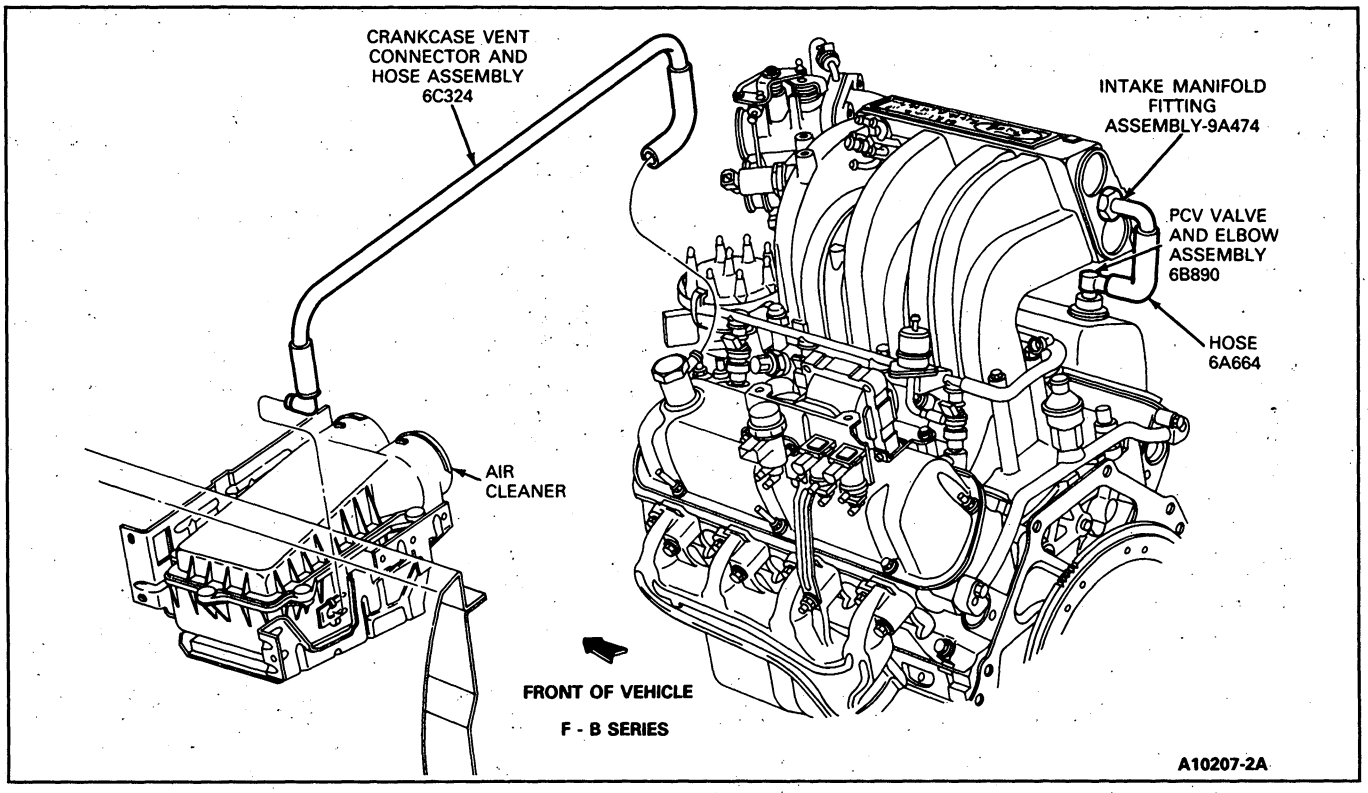


FIG. 14 Typical Crankcase Ventilation System—5.0L EFI (302 CID) V-8, 5.8L EFI (351 CID) W-V-8 Similar

Valve Spring, Retainer and Stem Seal

Removal

Broken valve springs or damaged valve stem seals and retainers may be replaced without removing the cylinder head, provided damage to the valve or valve seat has not occurred.

1. Remove rocker arm cover. Refer to Valve Rocker Arm Cover Removal and Installation.
2. Remove the applicable spark plug and bring the piston to the top of the bore to prevent accidental loss of the valve into the cylinder.
3. Remove the valve rocker arm fulcrum bolts, fulcrum seats, valve rocker arms and push rods from the applicable cylinder.
4. Install an air line with an adapter in the spark plug hole and apply air pressure to the cylinder (Fig. 17). Failure of the air pressure to hold the valve(s) in the closed position is an indication of valve seat damage and requires removal of the cylinder head.
5. Install the fulcrum bolt and position the Valve Spring Compressor Tool T70P-6049-A or equivalent as shown in Fig. 17. Compress the valve spring and remove the retainer locks, spring retainer, sleeve and valve spring.
6. Remove and discard the valve stem seal (Fig. 18).
7. **If air pressure has forced the piston to the bottom of the cylinder, any removal of air pressure will allow the valve(s) to fall into the cylinder. A rubber band, tape or string wrapped around the end of the valve stem will prevent this condition and will still allow enough travel to check the valve for binds.**
8. Inspect the valve stem for damage. Rotate the valve and check the valve stem tip for eccentric movement during rotation. Move the valve up and down through normal travel in the valve guide and check the stem for binds. **If the valve has been damaged, it will be necessary to remove the cylinder head. Refer to Section 21-01, General Gasoline Engine Service.**

Installation

1. If the condition of the valve proved satisfactory, lubricate the valve stem with engine oil of quality recommended in the Owner's Manual. Hold the valve in the closed position and apply air pressure within the cylinder.
2. Install a new valve stem seal on the valve guide (Fig. 18). Seal must be bottomed on guide. Place the spring in position over the valve and install the valve spring retainer and sleeve. Compress the valve spring and install the valve spring retainer locks. Remove the compressor tool and fulcrum bolt.
3. Lubricate the push rod ends with Multi-Purpose Grease D0AZ-19584-AA or equivalent, and install the push rod. Apply Multi-Purpose Grease D0AZ-19584-AA or equivalent to the tip of the valve stem.
4. Apply Multi-Purpose Grease D0AZ-19584-AA or equivalent to the rocker arms and fulcrum. Install the valve rocker arms, fulcrum and fulcrum bolts. Tighten to 25-33 N·m (18-25 ft-lb).
5. Turn off the air and remove the air line and adapter. Install the spark plug and connect the spark plug wire.
6. Clean and install the rocker arm cover.

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Intake Manifold

The intake manifold assemblies and gaskets are shown in Fig. 12.

Removal

1. Drain the cooling system. Remove the air cleaner and intake duct assembly, including the crankcase ventilation hose.
2. Disconnect the accelerator cable and speed control linkage, if so equipped, from the throttle body. Remove the accelerator cable bracket. Disconnect the automatic transmission kickdown rod at the throttle body.
3. Disconnect the high-tension lead and wires from the coil.
4. Disconnect the spark plug wires from the spark plugs by grasping, twisting and pulling the moulded cap using Spark Plug Wire Remover T74P-6666-A or equivalent (Fig. 15). Remove the wires and bracket assembly from the rocker arm cover attaching stud. Remove the distributor cap and spark plug wires as an assembly.
5. Remove the throttle body fuel inlet line (push-connect fittings). Refer to Section 24-50, Fuel Tanks and Lines for push-connect fitting removal.
6. Disconnect the distributor vacuum hoses from the distributor, if so equipped, or EEC distributor connection. Remove the distributor hold-down bolt and remove the distributor. Disconnect evaporative hoses.
7. Disconnect the radiator upper hose from the coolant outlet housing, and the water temperature sending unit wire at the sending unit. Remove the heater hose from the intake manifold.
8. Loosen the clamp on the water pump bypass hose at the coolant outlet housing and slide the hose off the outlet housing.
9. Disconnect the crankcase vent hose at the valve rocker arm cover.
10. Remove the intake manifold and throttle body as an assembly. **It may be necessary to pry the intake manifold away from the cylinder heads. Remove the intake manifold gaskets and seals.**

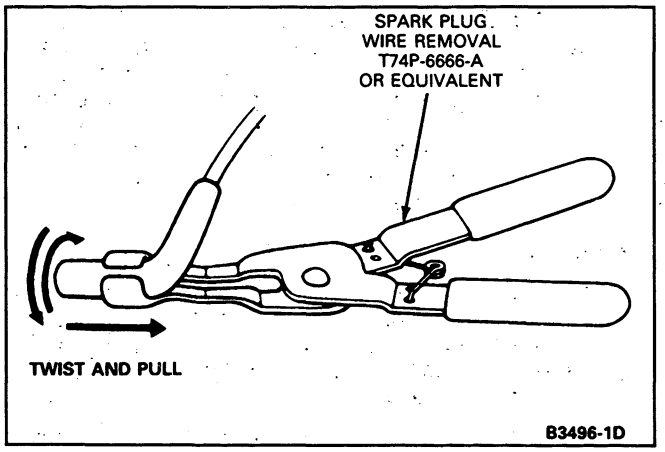


FIG. 15 Removing Wires from Spark Plugs

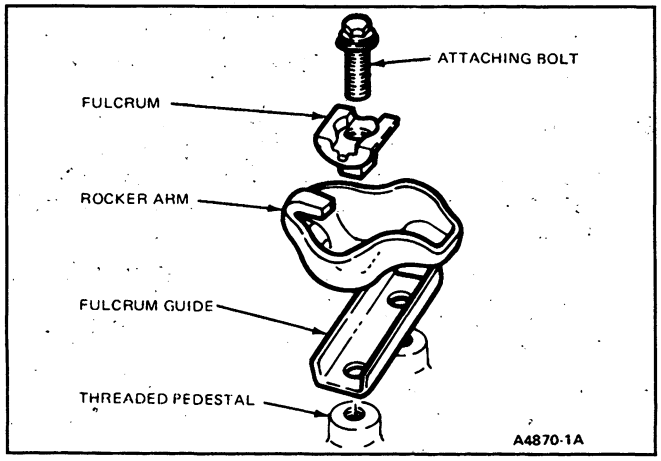


FIG. 16 Valve Rocker Arm Assembly

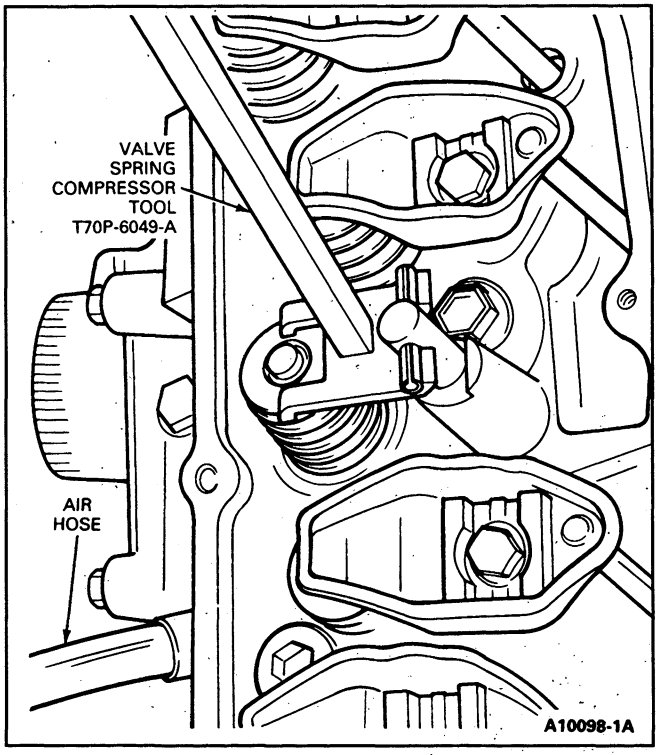


FIG. 17 Compressing Valve Spring—In Chassis

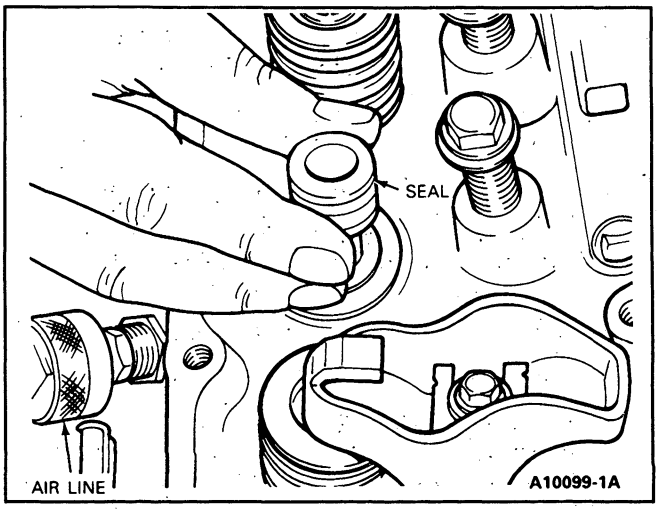


FIG. 18 Removing or Installing Valve Stem Seal

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11. Remove upper intake manifold 9425 and throttle body 9E926 as an assembly. Then, remove lower intake manifold assembly 9K461. **It may be necessary to pry the intake manifold away from the cylinder heads. Remove the intake manifold gaskets and seals. Discard the intake manifold attaching bolt sealing washer.**
12. If the manifold assembly is to be disassembled, identify all vacuum hoses before disconnecting them. Remove the coolant outlet housing gasket and thermostat. Remove the ignition coil, temperature sending unit, throttle body, spacer, gasket, vacuum fitting, accelerator retracting spring bracket.

Installation

1. If the intake manifold assembly was disassembled, install the temperature sending unit (threads coated with electrical conductive sealer), ignition coil, throttle body, spacer, gaskets, vacuum fitting, accelerator retracting spring bracket. Position the thermostat in the coolant outlet housing. Coat the new thermostat gasket with water-resistant sealer such as Ford Perfect Seal B5A-19554-A or equivalent, and position it on the coolant outlet housing. Install the coolant outlet housing. Tighten to 13-16 N·m (9-12 ft-lb). Connect all vacuum hoses.
2. Clean the mating surfaces of the intake manifold, cylinder heads and cylinder block using a solvent such as Ford Spot Remover B7A-19521-A or equivalent. Apply a 3.2mm (1/8-inch) bead of RTV Sealer D6AZ-19562-B or equivalent at the points shown in Fig. 19.
3. Apply a 1.6mm (1/16-inch) bead of RTV sealer to the outer end of each intake manifold seal for the full width of the seal (4 places) (Fig. 19).

   NOTE: This sealer sets up in 15 minutes, so it is important that assembly be completed promptly. Do not drip any sealer into the engine valley.

   Position the seals on the cylinder block and new gaskets on the cylinder heads with trademark toward cylinder head with the gaskets interlocked with the seal tabs. Be sure the holes in the gaskets are aligned with the holes in the cylinder heads.
4. Carefully lower the intake manifold into position on the cylinder block and cylinder heads. **After the intake manifold is in place, run a finger around the seal area to make sure the seals are in place. If the seals are not in place, remove the intake manifold and position the seals.**
5. Ensure holes in the manifold gaskets and manifold are in alignment. Install the intake manifold attaching nuts and bolts. Tighten all nuts and bolts in sequence (Fig. 20) to 32-33 N·m (23-25 ft-lb). After ten minutes retighten to the same specifications.
6. Install the water pump bypass hose on the coolant outlet housing. Slide the clamp into position and tighten the clamp.
7. Connect the radiator upper hose. Install the heater hose and connect the hose to the intake manifold.
8. Install the fuel inlet line.
9. Hook up vehicle chassis fuel supply and return lines to engine fuel rails.
10. Rotate the crankshaft damper until the No. 1 piston is on TDC at the end of the compression stroke. Install the distributor. Refer to Section 23-01, General Ignition Service for breakerless ignition systems.
11. Install the distributor cap, coil and solenoid brackets. Connect the spark plug wires and bracket assembly to attaching stud on rocker arm cover and connect the wires to the plugs.
12. Connect crankcase vent hose. Connect the high-tension lead and coil wires.
13. Connect accelerator cable and accelerator cable bracket. Connect speed control cable, if so equipped. Connect the automatic transmission kickdown rod/cable at the throttle body, if so equipped. Reconnect evaporative canister hoses.
14. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service.

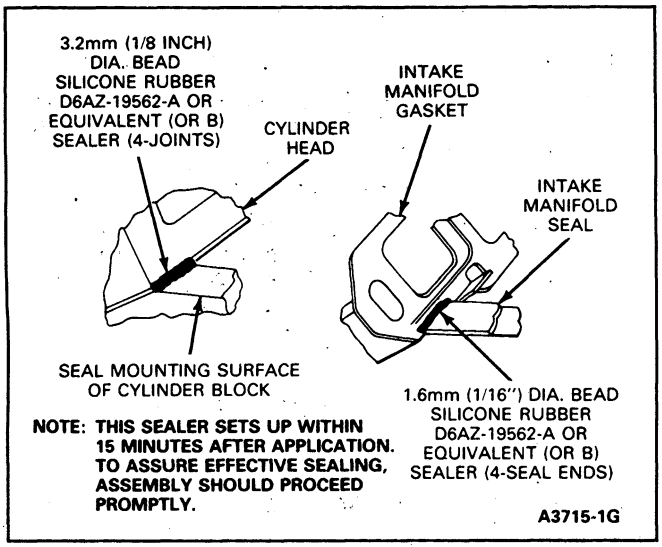


FIG. 19 RTV Sealer Installation—Intake Manifold

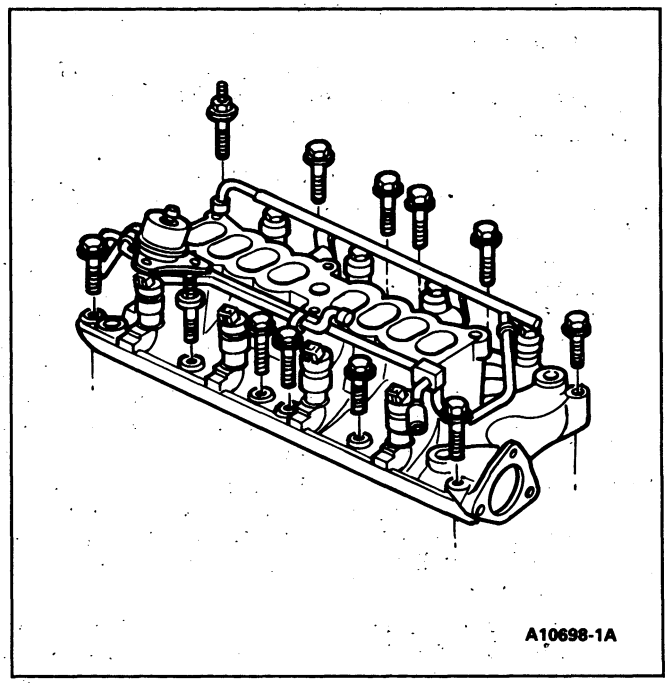


FIG. 20 Intake Manifold Bolts Tightening Sequence

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WARNING: DO NOT OPERATE THE ENGINE WITH THE HOOD OPEN UNTIL THE FAN HAS BEEN FIRST EXAMINED FOR POSSIBLE CRACKS AND SEPARATION.

15. Start the engine and check and adjust the ignition timing. Connect the distributor vacuum hoses or EEC connector, if so equipped.
16. Operate the engine at fast idle and check all hose connections and gaskets for leaks. Operate the engine until engine temperatures have stabilized and adjust the engine idle speed and idle fuel mixture to specifications on engine decal (5.0L EFI/5.8L EFI speeds/mixture controlled by computer). Re-tighten the intake manifold bolts in sequence (Fig. 20) to 32-33 N·m (23-25 ft-lb).
17. Adjust the transmission throttle linkage. Refer to Body, Chassis, Electrical Manual, Section 17-01 for adjustment procedure. Install the air cleaner and intake duct assembly, including the closed crankcase ventilation hose.

Tappet

Before replacing a hydraulic tappet for noisy operation, verify the noise is not caused by improperly adjusted valve-to-rocker arm clearance or by worn rocker arms or push rods.

Removal

1. Remove the intake manifold and related parts following procedures under Intake Manifold Removal.
2. Disconnect Thermactor air supply hose at the air pump and place it out of the way.
3. Remove the valve rocker arm cover, then loosen the valve rocker arm fulcrum bolts (Fig. 16) and rotate the rocker arms to the side.
4. Remove the valve push rods in sequence so that they can be installed in their original positions.
5. Using Hydraulic Tappet Puller T70L-6500-A or equivalent, shown in Fig. 21, remove the tappets and place them in a rack so that they can be installed in their original bores.

   If necessary to disassemble a tappet, refer to Tappet Disassembly and Assembly.

Installation

Tappets and bores are to be lubricated with engine oil of the quality recommended in the Owner's Manual before installation.

1. Clean the external surfaces and install the tappets in the bores from which they were removed using Hydraulic Tappet Puller T70L-6500-A or equivalent. If a new tappet(s) is being installed, check the new tappet(s) for a free fit in the bore in which it is to be installed. Lubricate the tappet(s) and bore(s) with recommended quality engine oil before inserting the tappet.
2. Lubricate the ends of the push rods with Multi-Purpose Grease D0AZ-19584-AA or equivalent and install the push rods in their original positions. Apply Grease D0AZ-19584-AA or equivalent to the valve stem tip.
3. Lubricate the rocker arms and fulcrum seats with Grease D0AZ-19584-AA or equivalent and position the rocker arms over the push rods. Tighten rocker arm fulcrum bolts to 25-33 N·m (18-25 ft-lb).

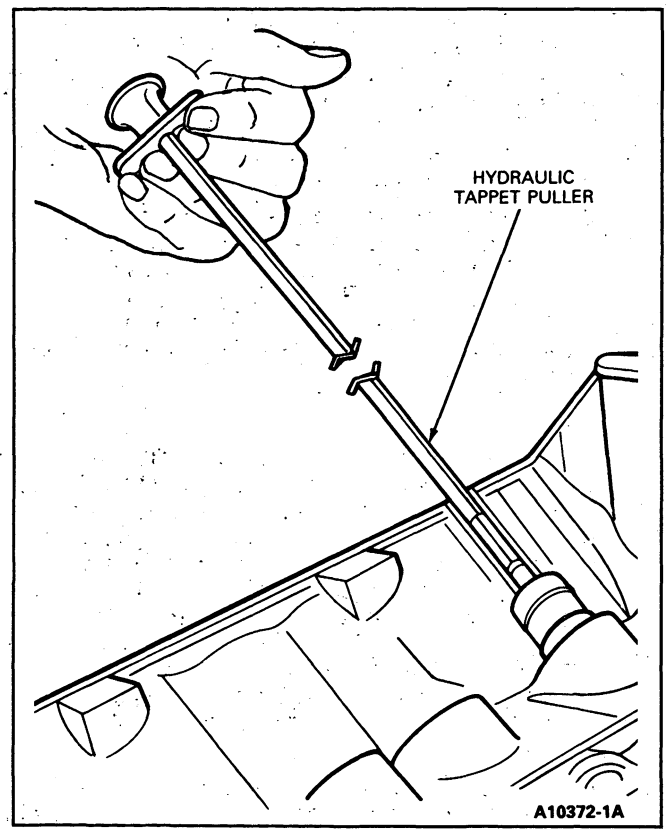


FIG. 21 Removing Valve Tappet

4. Install the valve rocker arm covers.
5. Reconnect Thermactor air supply hose.
6. Install the intake manifold following procedures under Intake Manifold Installation.

Cylinder Heads

If a cylinder head is to be replaced, follow the procedures under Cylinder Head Disassembly and Assembly, and transfer all valves, springs, spark plugs, etc., to the new cylinder head. Clean and inspect all parts, and reface the valves. Refer to Section 21-01, General Gasoline Engine Service. Check all assembly clearances before assembling the new or used parts to the new cylinder head.

Removal

1. Remove the intake manifold and throttle body as an assembly following the procedure under Intake Manifold Removal.
2. Remove the rocker arm cover(s).
3. If the RH cylinder head is to be removed, remove the alternator and air pump mounting bracket bolt and spacer. Swing the alternator down and out of the way. Remove the ignition coil (E-150—E-350) and air cleaner inlet duct from the LH cylinder head assembly.

   If the LH cylinder head is being removed, remove the bolts fastening the air conditioning compressor bracket at the front of the cylinder head on all F-series, remove oil dipstick and tube assembly and speed control bracket, if so equipped.
4. Disconnect the exhaust manifold(s) from the muffler inlet pipe(s).

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5. Loosen the rocker arm fulcrum bolts so that the rocker arms can be rotated to the side. Remove the push rods in sequence (Fig. 22) so that they may be installed in their original positions.
6. On E-150—E-350, remove the bolts holding the Thermactor air supply manifold to the rear of the cylinder head and disconnect the hose at the air pump. Remove hose, pump valve and air supply manifold as an assembly.
7. On F-150—F-350 and Bronco, disconnect the Thermactor air supply hoses at the check valves and plug the check valve.
8. Install the cylinder head holding fixtures. Remove the cylinder head attaching bolts and lift the cylinder head off the block. Remove and discard the cylinder head gasket.

Installation

1. Clean the cylinder head, intake manifold, valve rocker arm cover and cylinder head gasket surfaces. If the cylinder head was removed for a cylinder head gasket replacement, check the flatness of the cylinder head and block gasket surfaces. Refer to Section 21-01, General Gasoline Engine Service.
2. A specially treated composition gasket is used. **Do not apply sealer to a composition gasket. Position the new cylinder head gasket over the cylinder dowels on the block. Position the cylinder head on the block and install the attaching bolts. Remove the holding fixtures.**
3. The cylinder head bolts are tightened in three progressive steps, for the 5.8L EFI (351 CID) W-V-8, and in two steps for the 5.0L EFI (302 CID) V-8. Tighten all the bolts in sequence (Fig. 23) to:

   (For the 5.8L (351 CID) W-V-8)
   - first step—115 N·m (85 ft-lb)
   - second step—129 N·m (95 ft-lb)
   - third step—143-151 N·m (105-112 ft-lb)

   (For the 5.0L (302 CID) EFI V-8)
   - first step—75-88 N·m (55-65 ft-lb)
   - second step—88-97 N·m (65-72 ft-lb)

   When cylinder head bolts have been tightened following this procedure, it is not necessary to re-tighten the bolts after extended operation. However, the bolts may be checked and re-tightened if desired.
4. Clean the push rods in a suitable solvent. Blow out the oil passage in the push rod with compressed air. Check the ends of the push rods for nicks, grooves, roughness or excessive wear. Visually check the push rods for straightness or check push rod runout with a dial indicator. Refer to Section 21-01, General Gasoline Engine Service. If runout exceeds the maximum limit at any point, discard the rod. **Do not attempt to straighten push rods.**
5. Lubricate the end of the push rods with Multi-Purpose Grease D0AZ-19584-AA or equivalent and install them in their original positions. Apply Multi-Purpose Grease D0AZ-19584-AA or equivalent to the valve stem tips.
6. Lubricate the rocker arms and fulcrum seats with Multi-Purpose Grease D0AZ-19584-AA or equivalent, then install the rocker arms.
7. Position a new gasket(s) on the muffler inlet pipe(s), if so required. Connect the exhaust manifold(s) at the muffler inlet pipe(s). Tighten the nuts to 34-52 N·m (25-38 ft-lb).
8. If the right cylinder head was removed, swing the air pump into position and install the alternator attaching bolt and spacer, ignition coil (E-150—E-250) and air cleaner inlet duct on the RH cylinder head. Adjust the drive belt tension to specification. Refer to Section 27-06, Accessory Drive Belt Service.

   If the LH cylinder head was removed, install the air conditioning compressor bracket, if so equipped, at the front of the cylinder head. Install the oil dipstick and tube assembly and speed control bracket, if so equipped.
9. Clean the valve rocker arm cover gasket surfaces. Secure the new gaskets in the covers with gasket cement to ensure proper hole alignment. Install the valve rocker arm cover(s).
10. Install the intake manifold and related parts following the procedure under Intake Manifold Installation.
11. Install the Thermactor air supply manifold at the rear of the cylinder heads. Reconnect the air supply hose to the air pump (F-150), unplug the check valve and connect the Thermactor air supply hose.

Exhaust Manifolds

Removal

1. Remove air cleaner and intake duct assembly, including the crankcase ventilation hose.
2. Remove bolts attaching the air cleaner inlet duct (E-150—E-350), if so equipped.
3. Disconnect muffler inlet pipes.

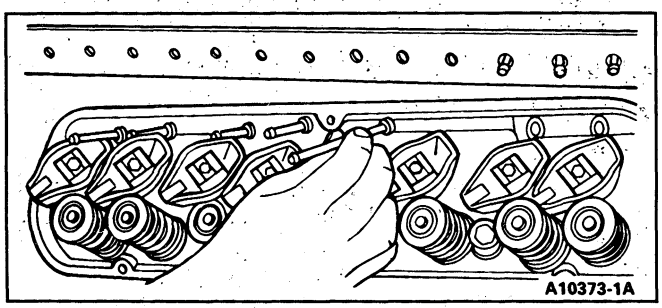


FIG. 22 Removing Valve Push Rods

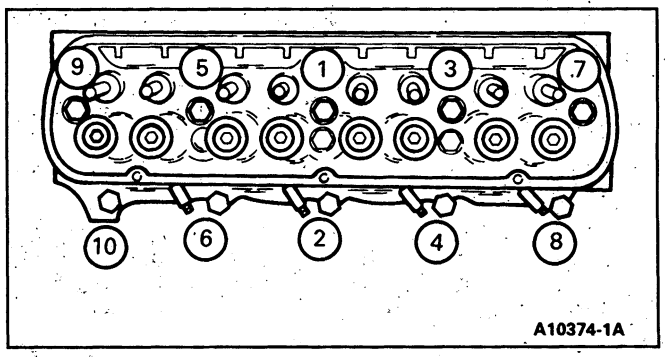


FIG. 23 Cylinder Head Bolt Tightening Sequence

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4. Remove the exhaust manifold heat shields, if so equipped, attaching bolts and flat washers. On the LH exhaust manifold remove oil dipstick tube assembly and speed control bracket and exhaust heat control valve, if so equipped. Then, remove the exhaust manifold.

Installation

1. Clean the mating surfaces of the exhaust manifold(s) and cylinder head(s). Clean the mounting flange spherical seat of the exhaust manifold(s) and muffler inlet pipe(s).
2. Position the exhaust manifold(s) on the cylinder head(s) and install attaching bolts and flat washers. On the LH exhaust manifold install oil dipstick tube assembly and the speed control bracket, if so equipped. Working from the center to the ends, tighten the bolts to 25-33 N·m (18-24 ft-lb).
3. Place a new gasket(s), if so equipped, on the muffler inlet pipe(s). Position the muffler inlet pipe(s) and exhaust heat control valve, if so equipped, into the manifold(s). Install and tighten the attaching nuts to 34-52 N·m (25-38 ft-lb).
4. Install air cleaner and intake duct assembly, including the crankcase ventilation hose.

Water Pump

F-150—F-350/Bronco

Removal

1. Drain the cooling system. Refer to Section 27-02, Cooling System Service.
2. Remove the bolts securing the fan shroud to the radiator, if so equipped. Position the shroud over the fan.
3. Disconnect the radiator lower hose, heater hose and bypass hose at the water pump. Remove the drive belts, fan, fan spacer and pulley. Remove the fan shroud, if so equipped.
4. Loosen the alternator pivot bolt and bolt attaching the alternator adjusting arm to water pump on 5.8L. Refer to Accessory Drive Belts, Section 27-06.
5. Remove the bolts securing the water pump to cylinder front cover. Remove the water pump (not required for 5.0L EFI). Remove power steering bracket and A/C compressor bracket for 5.0L EFI.

Installation

Before a water pump is installed, check it for damage. If it is damaged, replace it.

1. Remove all gasket material from the mounting surfaces of the cylinder front cover and water pump.
2. Position a new gasket, coated on both sides with Ford Perfect Seal B5A-19554-A or equivalent, on the cylinder front cover; then, install the pump.
3. Install the attaching bolts. Tighten bolts to 17-24 N·m (12-18 ft-lb).
4. Install the alternator pivot bolt and bolt attaching the alternator adjusting arm to the water pump on 5.8L EFI. Attach power steering bracket and A/C bracket (5.0L EFI).
5. Position the fan shroud over the water pump, if so equipped. Install the pulley, spacer and fan. Install and adjust the drive belts to the specified belt tension. Refer to Section 27-06, Accessory Drive Belt Service. Connect the radiator hose, heater hose and bypass hose. Install the fan shroud bolts, if so equipped.
6. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service. Operate the engine until normal operating temperatures have been reached and check for leaks.

E-150—E-350

Removal

1. Remove the air cleaner and intake duct assembly, including the crankcase ventilation hose.
2. Drain the cooling system. Refer to Section 27-02, Cooling System Service.
3. Disconnect the radiator upper hose at the engine and lower hose at the radiator. Remove the radiator attaching bolts and nuts. Remove the radiator. Refer to Section 27-04, Radiators.
4. Remove drive belts, fan, spacer and water pump pulley, if so equipped.
5. Disconnect heater hose and bypass hose at water pump.
6. Remove the bolts securing the water pump to the cylinder front cover. Remove the water pump.

Installation

Before a water pump is installed, check it for damage. If it is damaged, replace it.

1. Remove all gasket material from the mounting surfaces of the cylinder front cover and water pump.
2. Position a new gasket, coated on both sides with Ford Perfect Seal B5A-19554-A or equivalent, on the cylinder front cover; then, install the pump.
3. Install the attaching bolts and tighten to 17-24 N·m (12-18 ft-lb).
4. Connect the heater hose and bypass hose at the water pump.
5. Install the water pump pulley, spacer and fan drive belts, if so equipped. Refer to Section 27-06, Accessory Drive Belt Service.
6. Install the radiator. Refer to Section 27-04, Radiators. Connect lower hose at the radiator and upper hose at the engine.
7. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service. Operate the engine until normal operating temperatures have been reached and check for leaks.
8. Install the air cleaner and intake duct assembly, including the crankcase ventilation hose.

Cylinder Front Cover and Timing Chain

F-150—F-350/Bronco

Removal

1. Refer to Water Pump Removal. Perform all steps except removal of the pump. Leave it attached to the front cover.
2. Remove the crankshaft pulley from the crankshaft vibration damper. Remove the damper attaching bolt and washer. Install Damper Remover D80L-

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522-A, Crankshaft Damper Remover T58P-6316-D, Damper Remover/Replacer Tool T79T-6316-A or equivalents on the crankshaft vibration damper (Fig. 27) and remove the vibration damper.

3. Remove the oil pan-to-cylinder block front cover attaching bolts. Use a thin-bladed knife to cut the oil pan gasket flush with the cylinder block face prior to separating the cover from the cylinder block. Remove the cylinder front cover and water pump as an assembly.
4. Discard the cylinder front cover gasket
5. Check the timing chain deflection. Refer to Section 21-01, General Gasoline Engine Service. If deflection exceeds specifications listed at the end of this Section replace the chain and sprockets.
6. Crank the engine until the timing marks on the sprockets are positioned as shown in Fig. 25.
7. Remove the camshaft sprocket capscrew, washers and fuel pump eccentric. Slide both sprockets and the timing chain forward, and remove them as an assembly (Fig. 26).

Installation

1. Position the sprockets and timing chain on the camshaft (Fig. 25). Be sure the timing marks on the sprockets are positioned as shown in Fig. 25.
2. Install the fuel pump eccentric, washers and camshaft sprocket capscrew (Fig. 27). Tighten the sprocket capscrew to 55-61 N·m (40-45 ft-lb).
3. Clean the cylinder front cover, oil pan and the cylinder block gasket surfaces. Clean the oil pan gasket surface where the oil pan and front cover fasten.

   Install a new oil seal following procedures under Front Oil Seal Removal and Installation.
4. Lubricate the timing chain and sprockets with heavy engine oil.
5. Coat the gasket surface of the oil pan with sealer, then cut and position the required new gasket on the oil pan and apply sealer at the corners. Install the pan seal as required. Coat the gasket surfaces of the block and cover with Ford Perfect Seal B5A-19554-A or equivalent, and position a new gasket on the block.
6. Position the cylinder front cover on the cylinder block. Use care when installing the cover to avoid seal damage or possible gasket mislocation.
7. Install the cylinder front cover-to-seal alignment using Front Cover Aligner Tool T61P-6019-B or equivalent (Fig. 28).
8. It may be necessary to force the cover downward to slightly compress the pan gasket. This operation can be facilitated by using a suitable tool at the front cover attaching hole locations.
9. Coat the threads of the attaching screws with Ford Perfect Seal B5A-19554-A or equivalent and install the screws. While pushing in on the alignment tool, tighten the oil pan-to-cover attaching screws to 17-24 N·m (12-18 ft-lb). Tighten the cover-to-cylinder block attaching screws to 17-24 N·m (12-18 ft-lb). Remove the alignment tool.
10. Apply Multi-Purpose Grease D0AZ-19584-AA or equivalent to the oil seal rubbing surface of the vibration damper inner hub to prevent damage to the seal and to the front of the crankshaft for damper installation.

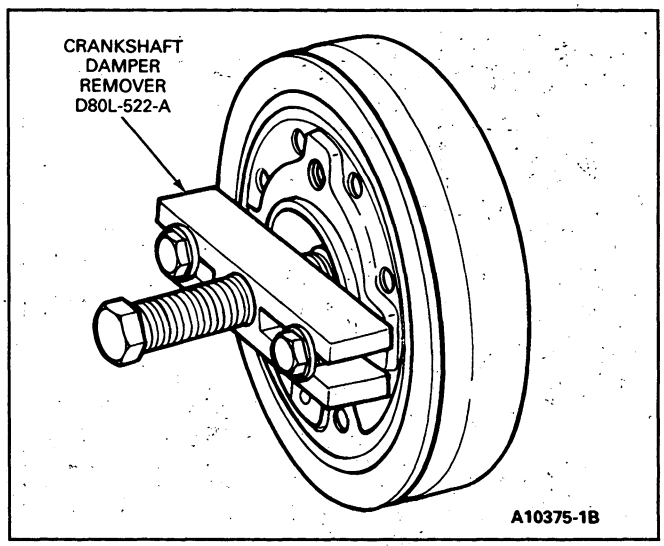


FIG. 24 Crankshaft Vibration Damper Removal—F-150 and F-350, Bronco

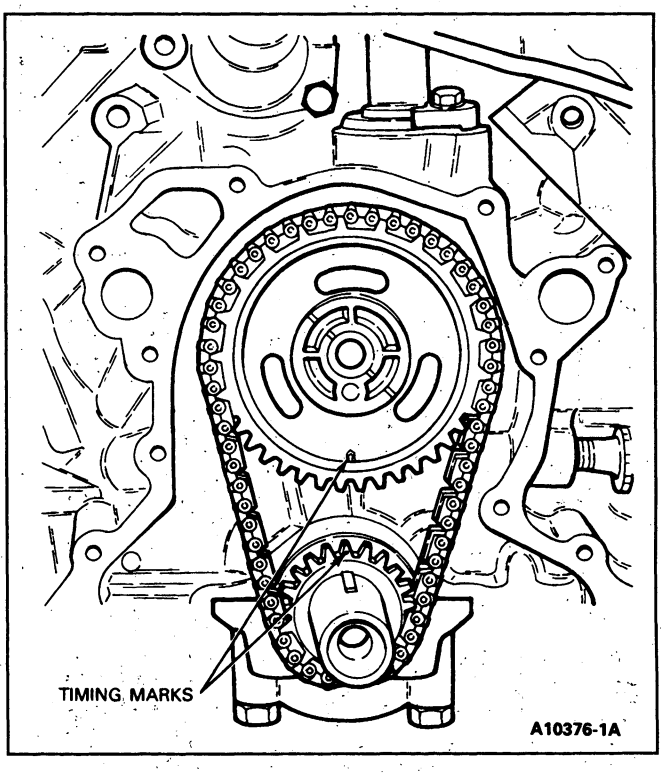


FIG. 25 Aligning Timing Marks

11. Line up the crankshaft vibration damper keyway with the key on the crankshaft. Install the vibration damper on the crankshaft using Damper Remover/Replacer Tool T79T-6316-A or equivalent (Fig. 31). Install the capscrew and washer. Tighten the screw to 95-122 N·m (70-90 ft-lbs). Install the crankshaft pulley.
12. Complete the remaining steps under Water Pump Installation.
13. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service.

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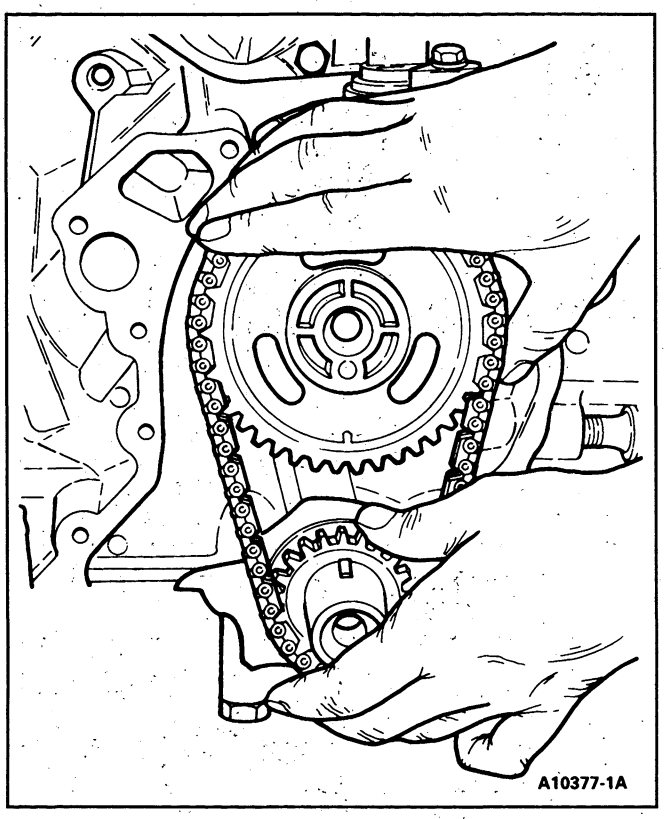


FIG. 26 Removing or Installing Timing Chain

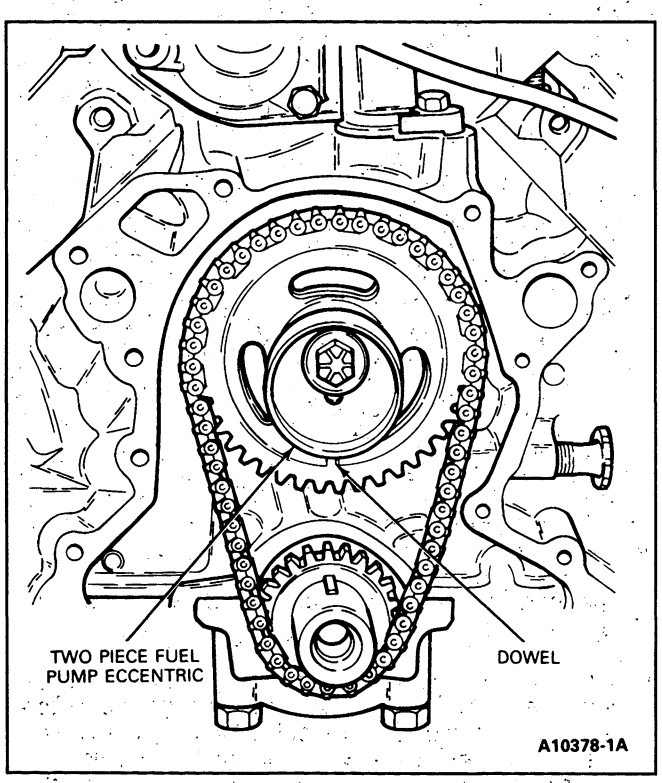


FIG. 27 Fuel Pump Eccentric—Installed

14. Operate the engine at fast idle and check the coolant level and check for oil leaks. Check and adjust the ignition timing to specifications on engine decal.
15. Install the air cleaner and intake duct assembly, including the crankcase ventilation hose.

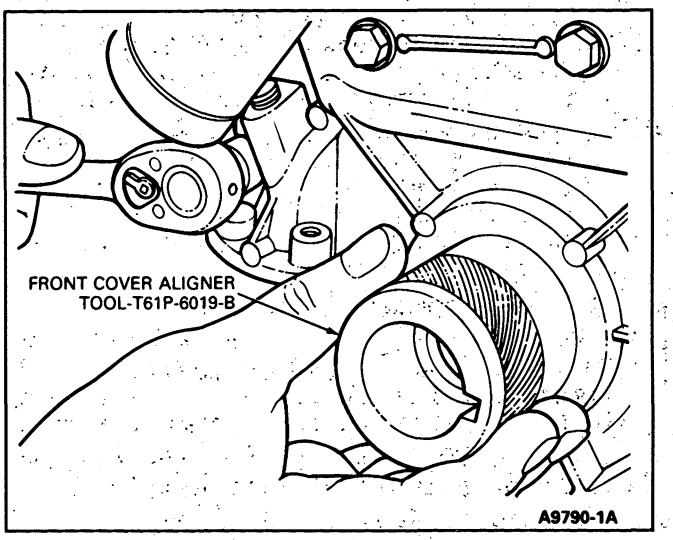


FIG. 28 Aligning Cylinder Front Cover

E-150—E-250

Removal

1. Drain radiator. Remove radiator. Refer to Section 27-04, Radiators. If so equipped, remove AC idler pulley and bracket and remove belt. Refer to Section 36-65, E-150—E-350 Air Conditioning System.
2. Remove upper radiator hose. Remove fan and shroud as an assembly. Raise vehicle on hoist.
3. Loosen Thermactor and alternator and remove drive belt (5.8L only).
4. Disconnect radiator lower hose at water pump. Disconnect fuel line at fuel pump and remove pump. Lower vehicle on hoist.
5. Remove bypass hose. If so equipped, remove power steering belt. Remove water pump pulley and disconnect heater hose at pump.
6. If so equipped, remove AC compressor upper bracket. Remove power steering pump mount from AC compressor and water pump.
7. Remove crankshaft pulley. Remove crankshaft vibration damper using Crankshaft Damper Remover T79T-6316-A (Fig. 46). Remove oil pan-to-front cover bolts. Remove front cover and water pump as an assembly.
8. Discard the cylinder front cover gasket.
9. Check the timing chain deflection. Refer to Section 21-01, General Gasoline Engine Service. If deflection exceeds 12.7mm (.500 inches), replace the chain and sprockets.
10. Crank the engine until the timing marks on the sprockets are positioned as shown in Fig. 25.
11. Remove the camshaft sprocket capscrew, washers and fuel pump eccentric. Slide both sprockets and the timing chain forward, and remove them as an assembly (Fig. 26).
12. Clean front cover, fuel pump and damper. Lubricate seal. Clean gasket surface at pan and trim gasket. Clean front cover gasket surface at block.

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Installation

1. Position the sprockets and timing chain on the camshaft (Fig. 26). Be sure the timing marks on the sprockets are positioned as shown in Fig. 25.
2. Install the fuel pump eccentric, washers and camshaft sprocket capscrew. Tighten the sprocket capscrew to 55-61 N·m (40-45 ft-lb).
3. Replace oil seal in front cover. Refer to Front Oil Seal. Position gasket to front cover. Apply RTV Silicone Sealer D6AZ-19562-B or equivalent to oil pan and cylinder block junction. Cut pan gasket, then position to pan and front cover.

   NOTE: When applying RTV Sealant always use the bead size specified and join the components within 15 minutes of application. After this amount of time the sealant begins to "set-up" and its sealing effectiveness may be reduced.
4. Install front cover. Install fuel pump. Install crankshaft vibration damper (Fig. 29). Install crankshaft pulley and water pump.
5. If so equipped, install power steering pump. Install bypass hose and connect heater hose.
6. If so equipped, install AC compressor upper bracket. Install water pump pulley. If so equipped, position power steering belt.
7. If so equipped, position alternator belt. Position Thermactor pump belt. Install fan and shroud.
8. If so equipped, adjust power steering belt tension. If so equipped, install AC idler pulley and bracket. Position belt and adjust tension. Refer to Section 27-06, Accessory Drive Belt Service.
9. Install radiator upper hose. Raise vehicle on hoist. Connect fuel lines at pump.
10. Connect radiator lower hose. Adjust alternator and Thermactor pump belt tension. Refer to Section 27-06, Accessory Drive Belt Service. Drain crankcase. Replace oil filter.
11. Lower vehicle on hoist. Install radiator. Refer to Section 27-04, Radiators. Fill crankcase. Fill and bleed cooling system. Refer to Section 27-02, Cooling System Service. Start engine and check for leaks.
12. Adjust engine timing to specification on engine decal.

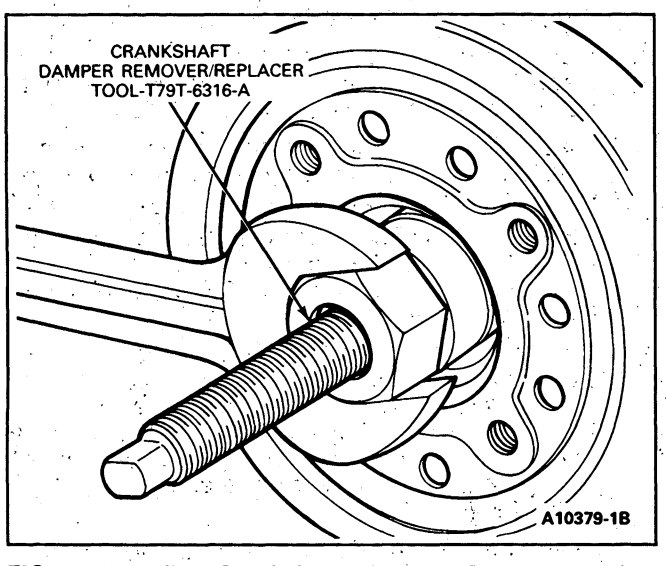


FIG. 29 Installing Crankshaft Vibration Damper

Front Oil Seal

Removal

1. Remove the bolts attaching the fan shroud to the radiator.
2. Remove the fan and spacer bolts from the water pump shaft. Remove the fan, spacer and shroud.
3. Loosen the alternator, power steering, Thermactor and air conditioner drive belts, if so equipped. Remove the drive belts.
4. Remove the crankshaft pulley from the vibration damper. Remove the damper attaching screw and washer. Install the puller on the crankshaft vibration damper (Fig. 27) and remove the vibration damper.
5. Place the Front Cover Seal Remover T70P-6B070-B or equivalent onto the front cover plate over the front seal as shown in Fig. 33. Tighten the two through bolts to force the seal puller under the seal flange.
6. Alternately tighten the four puller bolts one-half turn at a time as shown in Fig. 30 to pull the oil seal from the front cover.

Installation

1. Coat a new front cover plate oil seal with Lubriplate or equivalent. Place it onto the front oil seal onto Front Cover Seal Replacer T70P-6B070-A or equivalent (Fig. 31). Place the sleeve and seal onto the end of the crankshaft and push it toward the engine until the seal starts into the front cover.
2. Place the installation screw, washer and nut onto the end of the crankshaft. Thread the screw into the crankshaft. Tighten the nut against the washer and installation sleeve to force the seal into the front cover plate. Remove the installation tool from the crankshaft.
3. Apply Lubriplate or equivalent to the oil seal rubbing surface of the vibration damper inner hub to prevent damage to the seal. Apply a white lead and oil mixture to the front of the crankshaft for damper installation.
4. Line up the crankshaft vibration damper keyway with the key on the crankshaft. Install the vibration damper on the crankshaft (Fig. 29). Install the cap

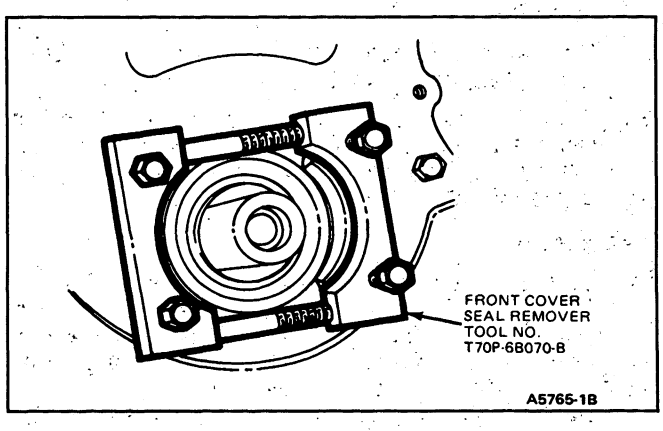


FIG. 30 Removing Front Crankshaft Seal

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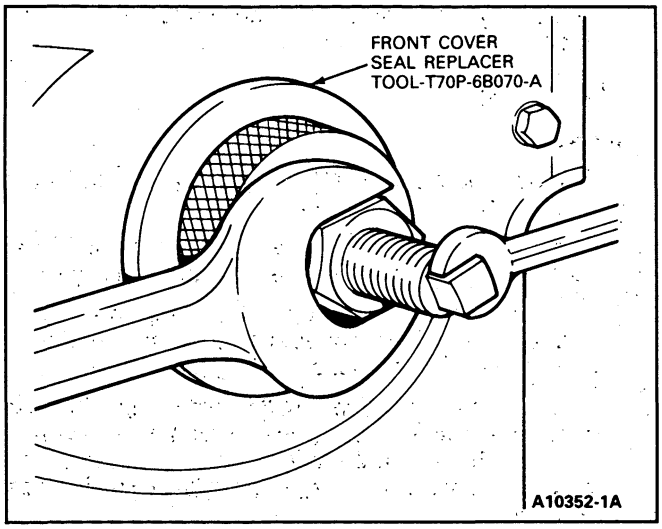


FIG. 31 Installing Front Crankshaft Seal

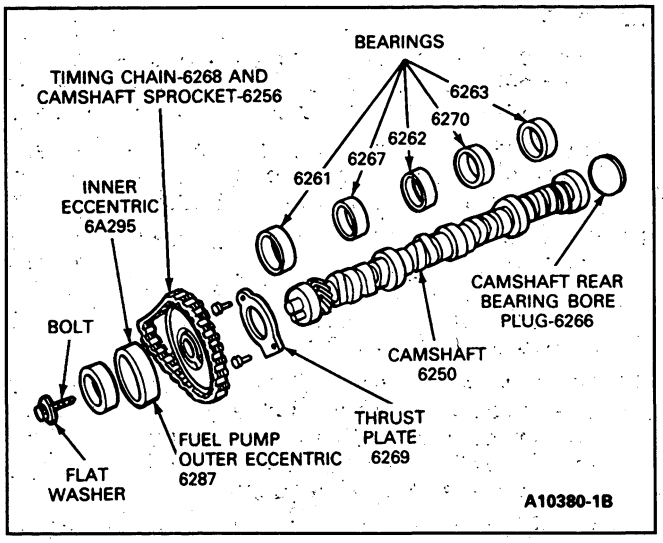


FIG. 32 Camshaft and Related Parts

screw and washer. Tighten the screw to 95-122 N·m (70-90 ft-lb). Install the crankshaft pulley.

5. Install the alternator, power steering pump, Thermactor and air conditioner belts, if so equipped.
6. Position the fan shroud over the water pump pulley. Install the fan and spacer. Install the fan shroud attaching screws.
7. Adjust the drive belts to specification. Refer to Section 27-06, Accessory Drive Belt Service.

Camshaft

The camshaft and related parts are shown in Fig. 32.

Removal

1. On E-150—E-350 vehicles only, remove the grille.
2. Drain the cooling system. Refer to Section 27-02, Cooling Systems Service. Disconnect the radiator upper and lower hoses. Disconnect the transmission oil cooler lines, if so equipped. Remove the radiator. Refer to Section 27-04, Radiators.
3. Remove the cylinder front cover and the timing chain following the procedure under Cylinder Front Cover and Timing Chain Removal.
4. Remove the intake manifold throttle body as an assembly following the procedures under Intake Manifold Removal.
5. Remove the tappets following the procedure given under Tappet Removal.
6. Remove the camshaft thrust plate. Carefully remove the camshaft by pulling toward the front of the engine. **Use caution to avoid damaging the camshaft bearings.**

Installation

1. Oil the camshaft journals and apply Multi-Purpose Grease D0AZ-19584-AA or equivalent to the lobes. Carefully slide the camshaft through the bearings. Lubricate the camshaft thrust plate with recommended quality engine oil and install the camshaft thrust plate with the groove toward the cylinder block.
2. Lubricate the tappets and tappet bores with heavy engine oil. Install the valve tappets in the bores from which they were removed (Fig. 21).
3. Lubricate the ends of the push rods with Multi-Purpose Grease D0AZ-19584-AA or equivalent and install the push rods in their original positions. Apply Multi-Purpose Grease D0AZ-19584-AA or equivalent to the valve stem tips. Lubricate the rocker arms and fulcrum seats with Multi-Purpose Grease D0AZ-19584-AA or equivalent and position the rocker arms over the push rods. Tighten bolts to 25-33 N·m (18-25 ft-lb).
4. Install the intake manifold and related parts by following the procedure under Intake Manifold Installation.
5. Replace the crankshaft front oil seal. Install the timing chain, cylinder front cover and related parts, following the procedure under Cylinder Front Cover and Timing Chain Installation.
6. Perform a valve clearance check as outlined.
7. Install the valve rocker arm covers following the procedures under Valve Rocker Arm Cover Installation.
8. Clean and install the crankcase ventilation system.
9. Install the radiator and connect the hoses. Refer to Section 27-04, Radiators. Connect the oil transmission cooler lines, if so equipped.
10. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service. Fill the crankcase with the proper grade and quantity of engine oil.
11. Start the engine, then check and adjust the ignition timing (refer to the engine decal for correct settings). Connect the distributor and intake manifold vacuum hoses.
12. Operate the engine at fast idle and check all hose connections and gaskets for leaks. Operate the engine until engine temperatures have stabilized, then adjust the engine idle speed and idle fuel mixture (refer to specifications on engine decal). Re-tighten intake manifold bolts and nuts to 32-33 N·m (23-25 ft-lb).
13. Install the air cleaner and intake duct assembly, including the crankcase ventilation hose.

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14. On E-150—E-350 vehicles, install the grille.

Flywheel

Removal

1. On a vehicle with a manual transmission, remove the transmission and flywheel housing, clutch pressure plate and disc. Refer to Group 16.

   On a vehicle with an automatic transmission, remove the transmission and converter housing. Refer to Group 17.
2. To check flywheel face runout or to replace a flywheel ring gear for a manual transmission, refer to Section 21-01, General Gasoline Engine Service.
3. Remove the flywheel attaching bolts and remove the flywheel.

Installation

1. Coat the threads of the flywheel attaching bolts with oil-resistant Threadlock and Sealer E0AZ-19554-A or equivalent. Position the flywheel on the crankshaft flange. Install and tighten the bolts in sequence across from each other to 102-115 N·m (75-85 ft-lb).
2. On a vehicle with a manual transmission, check the flywheel runout. Refer to Section 21-01, General Gasoline Engine Service. Install the clutch pressure plate, disc and the transmission and flywheel housing. Refer to Group 16.

   On a vehicle with an automatic transmission, check the flywheel runout. Refer to Section 21-01, General Gasoline Engine Service. Install the transmission and converter housing. Refer to Group 17.

Clutch Pilot Bearing

Removal

A needle roller bearing and adapter assembly is used as a clutch pilot bearing on E-150—E-350, F-150—F-350 and Bronco vehicles (Fig. 33). It is inserted directly into the engine crankshaft. The bearing and adapter assembly is used with the bearing and adapter comprising an assembly that cannot be serviced separately. The clutch pilot bearing can only be installed with the seal end of the bearing facing the transmission. The bearing and seal are pre-greased and do not require additional lubrication. A new bearing must be installed whenever a bearing is removed.

Removal

1. Remove the transmission and flywheel housing, clutch pressure plate, and disc. Refer to Group 16.
2. Using Impact Slide Hammer T59L-100-B and Puller Attachment T58L-101-B (Fig. 33) or equivalents, remove the pilot bearing (Fig. 34).

Installation

1. Using Pilot Bearing Replacer T74P-7137-A or equivalent, install the pilot bearing with the seal facing the transmission (Fig. 37) so that the adapter is not cocked.
2. Install the clutch pressure plate, disc, and transmission and flywheel housing. Refer to Group 16.

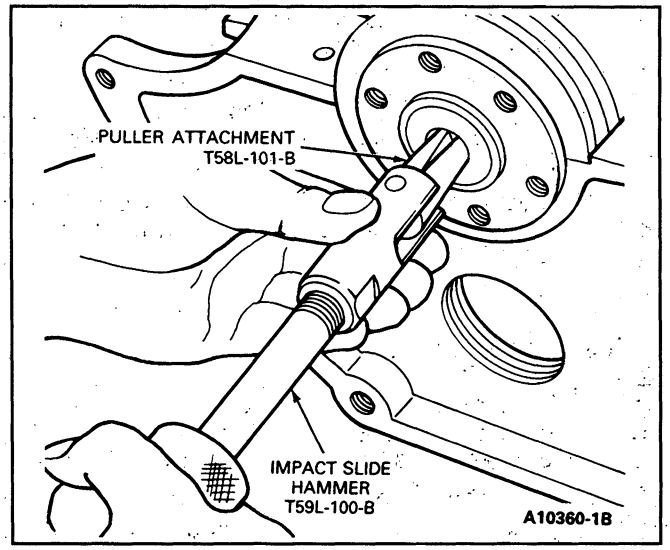


FIG. 33 Removing Clutch Pilot Bearing

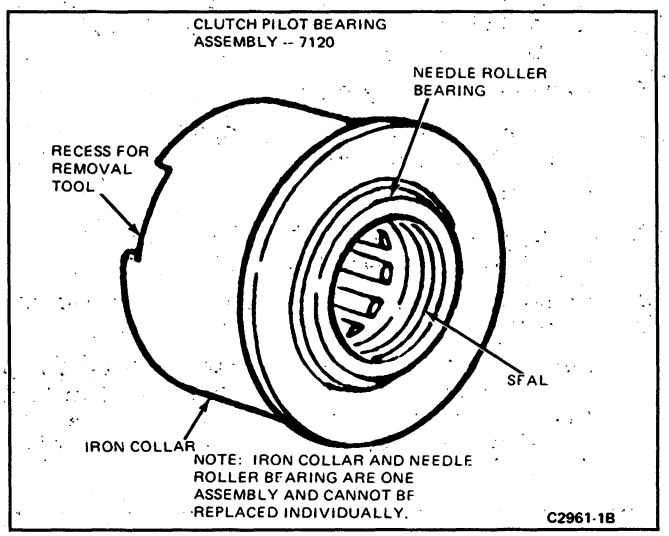


FIG. 34 Clutch Pilot Bearing Assembly

NOTE: Care must be taken not to damage the bearing during transmission installation while the transmission input shaft is being inserted into the bearing.

Camshaft Rear Bearing Bore Plug

Removal

1. On a vehicle with a manual transmission, remove the transmission and flywheel housing, clutch pressure plate and disc. Refer to Group 16.

   On a vehicle with an automatic transmission, remove the transmission and converter housing. Refer to Group 17.
2. Remove the flywheel attaching bolts and remove the flywheel. Remove the engine rear cover plate.
3. Replace the rear bearing bore plug. Refer to Section 21-01, General Gasoline Engine Service.

Installation

1. Coat the flywheel attaching bolts with oil-resistant Threadlock and Sealer E0AZ-19554-A or equivalent. Position the engine rear cover plate on the cylinder block dowels. Position the flywheel on

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the crankshaft flange. Install and tighten the attaching bolts in sequence, across from each other, to 102-115 N·m (75-85 ft-lb).

2. On a vehicle with a manual transmission, install the clutch pressure plate, disc and the transmission and flywheel housing. Refer to Group 16.
3. On a vehicle with an automatic transmission, install the transmission and converter housing. Refer to Group 17.

Oil Pan

F-150—F-350/Bronco

Removal

1. Remove the bolts attaching the fan shroud to the radiator and position the shroud over the fan.
2. Remove the upper intake manifold.
3. Remove the nuts and lock washers attaching the engine support insulators to the chassis bracket.
4. If equipped with an automatic transmission, disconnect the oil cooler line at the LH side of the radiator.
5. Remove exhaust system.
6. Raise the engine and place wood blocks securely under the engine supports.
7. Drain the crankcase.
8. Support transmission with jack stand and remove transmission crossmember.
9. Remove the oil pan attaching bolts and lower the oil pan onto the crossmember.
10. Remove the two bolts attaching the oil pump pickup tube to the oil pump. Remove nut attaching oil pump pickup tube to the number 3 main bearing cap stud. Lower the pickup tube and screen into the oil pan.
11. Remove the oil pan from the vehicle.

Installation

1. Clean oil pan, inlet tube and gasket surfaces. Inspect the gasket sealing surface for damages and distortion due to overtightening of the bolts. Repair and straighten as required.
2. Position a new oil pan gasket to the cylinder block (Fig. 36).
3. Position the oil pickup tube and screen to the oil pump, and install the lower attaching bolt and gasket loosely. Install nut attaching to number 3 main bearing cap stud.
4. Install the upper pickup tube bolt. Tighten the pickup tube bolts to specifications.
5. Position the oil pan to the cylinder block and install the attaching bolts. Tighten to 13-14 N·m (9-11 ft-lb).
6. Install the transmission crossmember and remove jack stand.
7. Raise the engine and remove the wood blocks. Lower the engine and install the insulator-to-chassis bracket nuts and washers. Tighten the nuts to 73-100 N·m (54-74 ft-lb).
8. Install the exhaust system.
9. If equipped with an automatic transmission, connect the oil cooler line at the radiator.
10. Install the upper intake manifold.
11. Install the fan shroud attaching bolts.
12. Fill the crankcase with the proper grade and quantity of engine oil. Install the oil dipstick. Start the engine and operate it until it reaches normal operating temperature, then check for leaks.

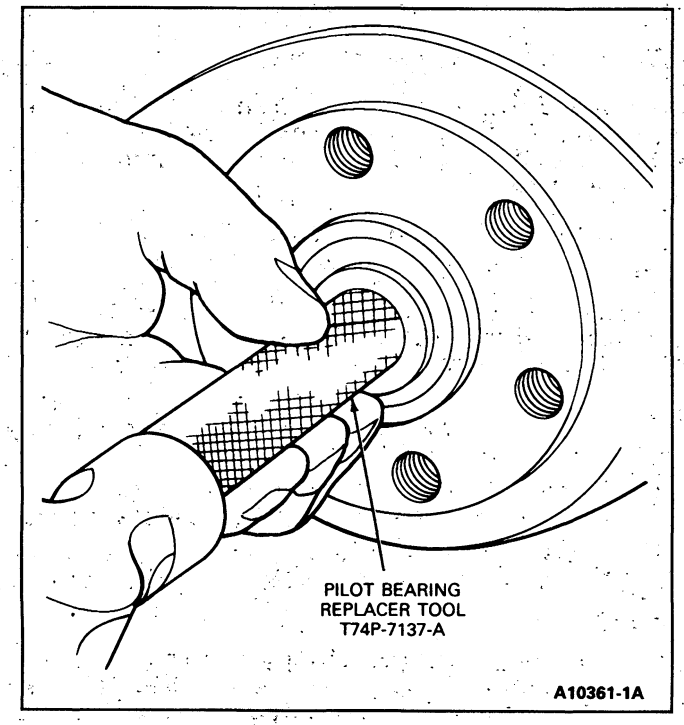


FIG. 35 Installing Clutch Pilot Bearing

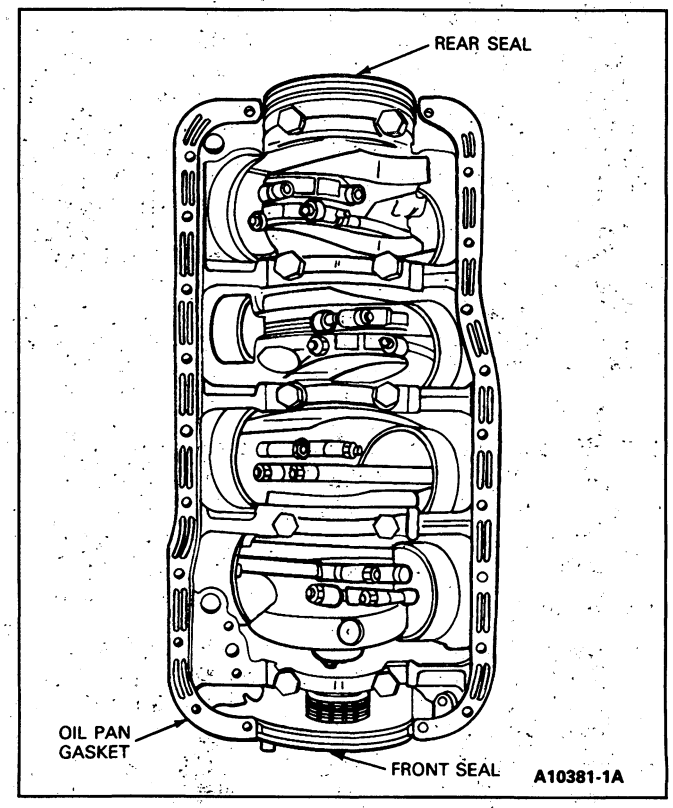


FIG. 36 Oil Pan Gasket Installed

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E-150—E-350

Removal

1. Open hood and disconnect battery. Open door and remove engine cover. Remove air cleaner. Drain cooling system. Refer to Section 27-02, Cooling System Service.
2. If so equipped, loosen power steering pump and remove belt. Remove power steering pump from mount and position out of way. If so equipped, remove A/C compressor retainers and position compressor out of way. Refer to Section 36-65, E-150—E-350 Air Conditioning System.
3. Disconnect radiator upper hose. Remove fan shroud bolts and oil filler tube. Remove oil dipstick-to-exhaust manifold bolt. Raise vehicle on hoist.
4. Remove splash shield under alternator. If so equipped, disconnect transmission cooler lines at radiator. Disconnect radiator lower hose.
5. Disconnect fuel line at fuel rail. Remove engine mount nuts. Drain crankcase. Remove the dipstick tube from oil pan. Disconnect muffler inlet pipe from manifolds.
6. If so equipped, remove automatic transmission dipstick and tube. Disconnect manual linkage at transmission. Remove center driveshaft support and remove driveshaft from transmission.
7. Place a transmission jack under the oil pan and insert a wooden block between the pan and jack. **The engine and transmission assembly will pivot around the rear engine mount. The engine assembly must be raised 102mm (four inches) measured from the front motor mounts. The engine must remain centered in the engine compartment to obtain this much lift.**
8. Raise the engine and transmission assembly. Insert wood blocks to support engine in uppermost position.
9. Remove the oil pan attaching bolts and lower the oil pan. Unbolt the oil pump and pickup tube and lay in pan (except on 5.8L (351 CID) W-V-8 E-150—E-350 models). Remove nut attaching pickup tube to number 3 main bearing cap stud. Remove oil pan from vehicle.

Installation

1. Clean oil pan, pickup tube, pump and gasket surfaces. Inspect gasket sealing surfaces for damage or distortion from overtightened bolts.
2. Position new gasket and seals to block (Fig. 34). Position pan with pump to engine and install pump. Install nut attaching pickup tube to number 3 main bearing cap stud. Install oil pan and tighten attaching bolts to 13-14 N·m (9-11 ft-lb). Install dipstick tube.
3. Position transmission jack, raise engine, remove wood blocks, lower engine and remove jack. Install front insulator attaching nuts and tighten to 68-95 N·m (50-70 ft-lb).
4. Install driveshaft and center driveshaft support. Connect manual linkage at transmission. Install muffler inlet pipe. Tighten nuts to 34-52 N·m (25-38 ft-lb). Install transmission filler tube. Connect radiator lower hose.
5. If so equipped, connect transmission cooler lines to radiator. Connect fuel line to pump fuel rail. Install alternator splash shield. Lower vehicle on hoist.
6. Install radiator shroud and connect radiator upper hose. If so equipped, install power steering pump. Position power steering belt and adjust belt tension. Refer to Section 27-06, Accessory Drive Belt Service. Install bolt attaching dipstick tube to exhaust manifold.
7. If so equipped, install A/C compressor. Refer to Section 36-65, E-150—E-350 Air Conditioning System. Position A/C belt and adjust belt tension. Refer to Section 27-06, Accessory Drive Belt Service.
8. Install oil filler tube and install air cleaner. Fill crankcase and fill and bleed cooling system. Refer to Section 27-02, Cooling System Service.
9. Connect battery. Start engine and check for leaks. Install engine cover. Close hood and door.

Oil Pump

Removal

NOTE: On E-150—E-250 5.0L (302 CID) V-8 engine vehicles the oil pump and oil pan must be removed and installed together. Refer to the E-150—E-350 Oil Pan Removal and Installation procedures.

F-150—F-350 and Bronco

1. Remove the oil pan and related parts as outlined under Oil Pan Removal.
2. Remove the oil pump inlet tube and screen assembly.
3. Remove the oil pump attaching bolts (Fig. 37), and intermediate drive shaft.

Installation

1. Prime the oil pump by filling the inlet port with engine oil. Rotate the pump shaft to distribute the oil within the pump body.
2. Position the intermediate drive shaft into the distributor socket. With the shaft firmly seated in the distributor socket, the stop on the shaft should touch the roof of the crankcase. Remove the shaft and position the stop as necessary.
3. With the stop properly positioned, insert the intermediate drive shaft into the oil pump. Install the pump and shaft as an assembly. **Do not attempt to force the pump into position if it will not seat readily. The drive shaft hex may be misaligned with the distributor shaft. To align, rotate the intermediate drive shaft into a new position.** Tighten the oil pump attaching screws to 30-43 N·m (22-32 ft-lb).
4. Clean and install the oil pump inlet tube and screen assembly.
5. Install the oil pan and related parts as outlined under Oil Pan Installation.

Crankshaft Rear Oil Seal

For replacement of a crankshaft rear oil seal refer to Crankshaft Rear Oil Seal Replacement in Section 21-01, General Gasoline Engine Service.

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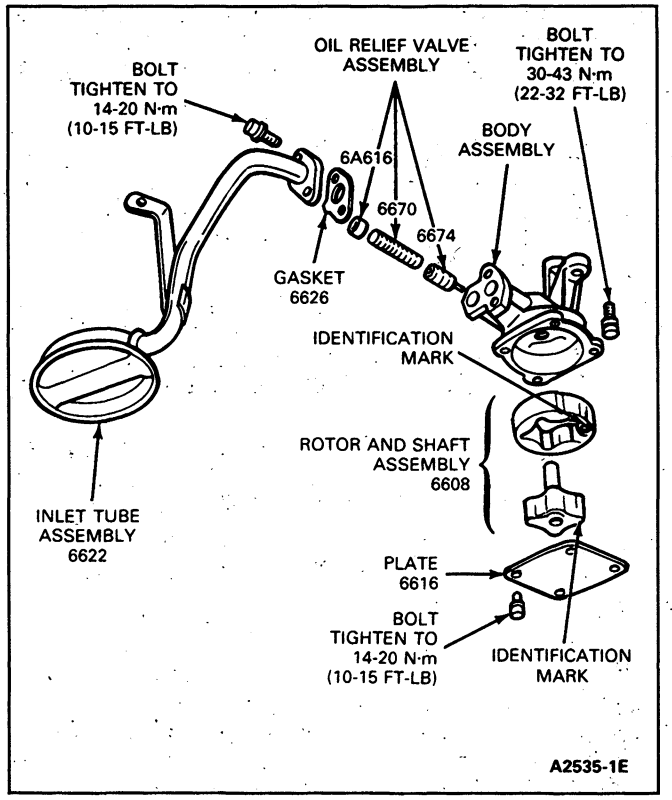


FIG. 37 Oil Pump and Inlet Tube

Main Bearing

The main bearing inserts are selective fit. Refer to the procedures under Fitting Main and Connecting Rod Bearings in Section 21-01, General Gasoline Engine Service.

Removal

1. Drain the crankcase. Remove the oil level dipstick. Remove the oil pan and related parts following the procedure under Oil Pan Removal.
2. Remove the oil pump inlet tube assembly and the oil pump.
3. Replace one bearing at a time, leaving the other bearings securely fastened. Remove the main bearing cap to which new bearings are to be installed.
4. Insert Upper Main Bearing Insert Remover and Replacer TOOL-6331-E or equivalent in the oil hole in the crankshaft (Fig. 38).
5. Rotate the crankshaft in the direction of engine rotation to force the bearing out of the block.
6. Clean each crankshaft journal. Inspect the journals and thrust faces (thrust bearing) for nicks, burrs or bearing pickup that would cause premature bearing wear.
7. If the rear main bearing is being replaced, remove and discard the rear oil seal from the bearing cap.
8. Remove the block half of the rear oil seal following the procedures under Crankshaft Rear Oil Seal Removal, Section 21-01, General Gasoline Engine Service.

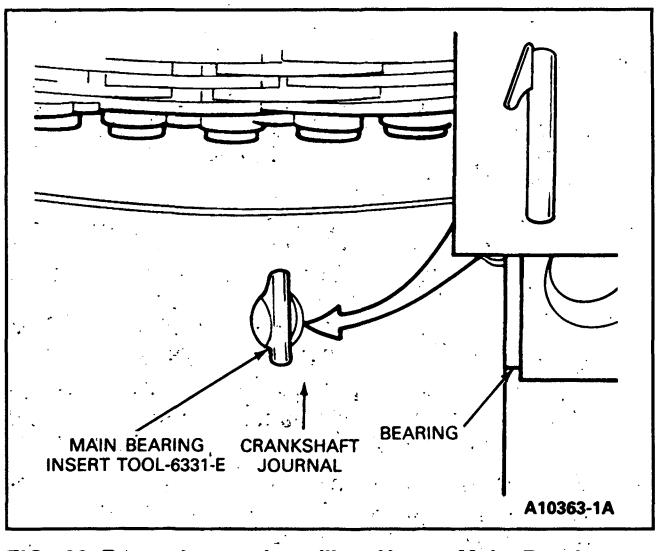


FIG. 38 Removing or Installing Upper Main Bearing Insert

Installation

1. If the rear main bearing is being replaced, clean the rear oil seal groove in the block with a brush and solvent.
2. Install the block half of the rear oil seal following the procedures under Crankshaft Rear Oil Seal Installation, Section 21-01, General Gasoline Engine Service.
3. To install an upper main bearing, place the plain end of the bearing over the shaft on the locking tang side of the block and partially install the bearing so that Upper Main Bearing Insert Remover and Replacer TOOL-6331-E or equivalent can be inserted in the oil hole in the crankshaft (Fig. 37). With Upper Main Bearing Insert Remover and Replacer TOOL-6331-E or equivalent in the hole in the crankshaft, rotate the crankshaft in the opposite direction of engine rotation until the bearing seats itself. Remove the tool.
4. Install the bearing cap.
5. Select fit the bearing for proper clearance following the procedures under Fitting Main and Connecting Rod Bearings in Section 21-01, General Gasoline Engine Service.
6. If the bearing is being replaced on journal number 1, 2 or 4, apply a coat of engine oil of the quality recommended in the Owner's Manual to the journal and bearings and install the bearing cap. Tighten the cap bolts. On 5.0L (302 CID) V-8 tighten cap bolts to 82-94 N·m (60-70 ft-lb); on 5.8L EFI (351 CID) W-V-8 tighten to 129-142 N·m (95-105 ft-lb).
7. Clean the oil seal groove with a brush and solvent.
8. Install the lower seal in the rear main bearing cap with the undercut side of the seal toward the FRONT of the engine. Allow the seal to protrude approximately 9.53mm (3/8 inch) above the parting surface to mate with the upper seal when the cap is installed.
9. Refer to Section 21-01, General Gasoline Engine Service for instructions in applying RTV sealer to the rear main bearing cap. Lubricate the journal

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with engine oil of the quality recommended in the Owner's Manual and install the rear main bearing cap. Tighten the cap bolts on 5.0L EFI (302 CID) V-8 to 82-94 N·m (60-70 ft-lb); on 5.8L EFI (351 CID) W-V-8 to 129-142 N·m (95-105 ft-lb).

10. If the thrust bearing cap (No. 3 main bearing) has been removed, install it as follows:

    Lubricate the journal with engine oil of the quality recommended in the Owner's Manual and install the thrust bearing cap with the bolts finger tight. Pry the crankshaft forward against the thrust surface of the upper half of the bearing (Fig. 39). Hold the crankshaft cap to the rear. This will align the thrust surfaces of both halves of the bearing. Retain the forward pressure on the crankshaft. Tighten the cap bolts on 5.0L EFI (302 CID) V-8 to 82-94 N·m (60-70 ft-lb); on 5.8L EFI (351 CID) W-V-8 to 129-142 N·m (95-105 ft-lb) (Fig. 39).

11. Clean the oil pump inlet tube screen. Prime the oil pump by filling the inlet opening with oil and rotating the pump shaft until oil emerges from the outlet opening. Install the oil pump and inlet tube assembly.

12. Position the oil pan gaskets on the oil pan. Install the oil pan and related parts following the procedure under Oil Pan Installation. Install the oil level dipstick.

13. Fill the crankcase. Start the engine and check for oil pressure. Operate the engine at fast idle and check for oil leaks.

Connecting Rod Bearings

The connecting rod bearings are selective fit. Refer to Fitting Main and Connecting Rod Bearings in Section 21-01, General Gasoline Engine Service.

Removal

1. Drain the crankcase. Remove the oil level dipstick. Remove the oil pan and related parts, following the procedure under Oil Pan Removal.
2. Remove the oil pump inlet tube assembly and the oil pump.
3. Turn the crankshaft until the connecting rod to which new bearings are to be fitted is down. Remove the connecting rod cap. Remove the bearing inserts from the rod and cap.

Installation

1. Be sure the bearing inserts and the bearing bore in the connecting rod and cap are clean. Foreign material under the inserts will distort the bearing and cause a failure.
2. Clean the crankshaft journal.
3. Install the bearing inserts in the connecting rod and cap with the tangs fitting in the slots provided.
4. Pull the connecting rod assembly down firmly on the crankshaft journal.
5. Select fit the bearing. Refer to Fitting Main and Connecting Rod Bearings in Section 21-01, General Gasoline Engine Service.
6. After the bearing has been fitted, clean and apply a coat of engine oil of the quality recommended in the Owner's Manual to the journal and bearings. Install the connecting rod cap. Tighten the nuts on 5.0L EFI (302 CID) V-8 to 26-32 N·m (19-24 ft-lb); on 5.8L EFI (351 CID) W-V-8 to 55-61 N·m (40-45 ft-lb).
7. Repeat the procedure for the remaining connecting rods that require new bearings.
8. Clean the oil pump inlet tube screen. Prime the oil pump by filling the inlet opening with oil and rotating the pump shaft until oil emerges from the outlet opening. Install the oil pump and inlet tube assembly.
9. Position the oil pan gaskets on the cylinder block. Position the oil pan front seal on the cylinder block front cover and interlock the seal with the gaskets. Position the oil pan rear seal on the rear main bearing cap and interlock the seal with the gaskets. Install the oil pan and related parts following the procedure under Oil Pan Installation. Install the oil level dipstick.
10. Fill the crankcase with engine oil of the quality and quantity recommended in the Owner's Manual. Start the engine and check for oil pressure. Operate the engine at fast idle and check for oil leaks.

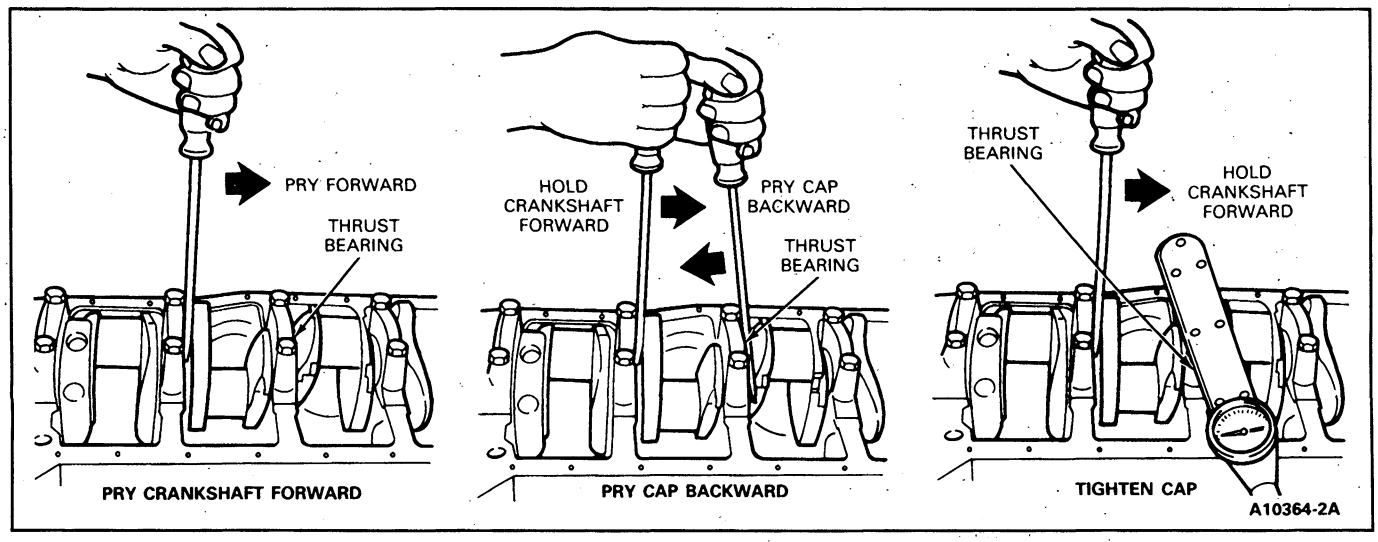


FIG. 39 Aligning Thrust Bearing

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Pistons and Connecting Rods

Removal

1. Drain the cooling system. Refer to Section 27-02, Cooling System Service. Drain the crankcase. Remove the intake manifold, cylinder heads, oil pan and oil pump as outlined.
2. Remove any ridges and/or deposits from the upper end of the cylinder bores as follows.

   Turn the crankshaft until the piston to be removed is at the bottom of its travel, then place a cloth on the piston head to collect the cuttings. Remove the cylinder ridge with a ridge cutter. Follow the instructions furnished by the tool manufacturers. **Never cut into the ring travel area in excess of 0.794 mm (1/32 inch) when removing ridges.**
3. Ensure all connecting rod caps are marked so that they can be installed in their original positions.
4. Turn the crankshaft until the connecting rod being removed is down.
5. Remove the connecting rod nuts and cap.
6. Push the connecting rod and piston assembly out the top of the cylinder with the handle end of a hammer. **Avoid damage to the crankshaft journal or the cylinder wall when removing the piston and rod.**
7. Remove the bearing inserts from the connecting rod and caps.
8. Install the cap on the connecting rod from which it was removed.

Installation

1. If new piston rings are to be installed, remove the cylinder wall glaze. Follow the instructions of the tool manufacturer.
2. Install rings using a piston ring installation tool of the proper size.
3. Oil the piston rings, pistons and cylinder walls with recommended quality engine oil. **Be sure to install the pistons in the same cylinders from which they were fitted.** The connecting rod and bearing caps are numbered from 1 to 4 in the RH bank and from 5 to 8 in the LH bank, beginning at the front of the engine. The numbers on the connecting rod and bearing cap must be on the same side when installed in the cylinder bore. If a connecting rod is ever transferred from one block or cylinder to another, new bearings should be fitted and the connecting rod should be numbered to correspond with the new cylinder number.

   When installing the piston and connecting rod assembly, the largest chamfer at the bearing end of the rod should be positioned toward the crank pin thrust face of the crankshaft.
4. Ensure the ring gaps (oil ring spacer-A, oil ring-B, compression ring-C) are properly spaced around the circumference of the piston (Fig. 40).
5. Install Piston Ring Compressor D81L-6002-C or equivalent on the piston and push the piston in with a hammer handle until it is slightly below the top of the cylinder (Fig. 41). Be sure to guide the connecting rods to avoid damaging the crankshaft journals. Install the piston with the indentation notch in the piston head toward the front of the engine.
6. Check the clearance of each bearing. Refer to Fitting Main and Connecting Rod Bearings in Section 21-01, General Gasoline Engine Service.
7. After the bearings have been fitted, apply a light coat of recommended engine oil to the journals and bearings.
8. Turn the crankshaft throw to the bottom of its stroke. Push the piston all the way down until the connecting rod bearing seats on the crankshaft journal.
9. Install the connecting rod cap. Tighten the nuts on 5.0L EFI (302 CID) V-8 to 26-32 N·m (19-24 ft-lb); on 5.8L EFI (351 CID) W-V-8 to 55-61 N·m (40-45 ft-lb).
10. After the piston and connecting rod assemblies have been installed, check the side clearance between the connecting rods on each shaft journal (Fig. 42).
11. Disassemble, clean, and assemble the oil pump. Clean the oil pump inlet tube screen and the oil pan and block gasket surfaces.
12. Prime the oil pump by filling the inlet port with engine oil of the quality recommended in the Owner's Manual and rotating the pump shaft to distribute the oil within the housing. Install the oil pump and the oil pan following the procedures under Oil Pan Installation.
13. Install the cylinder heads following the steps under Cylinder Head Installation.
14. Install the intake manifold following the steps under Intake Manifold Installation.
15. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service. Fill the crankcase with the proper quality and quantity of engine oil as recommended in the Owner's Manual.
16. Start the engine, then check and adjust the ignition timing. Connect the distributor vacuum hoses to the distributor.
17. Operate the engine at fast idle and check for oil and coolant leaks. Operate the engine until engine temperatures have stabilized, then adjust the

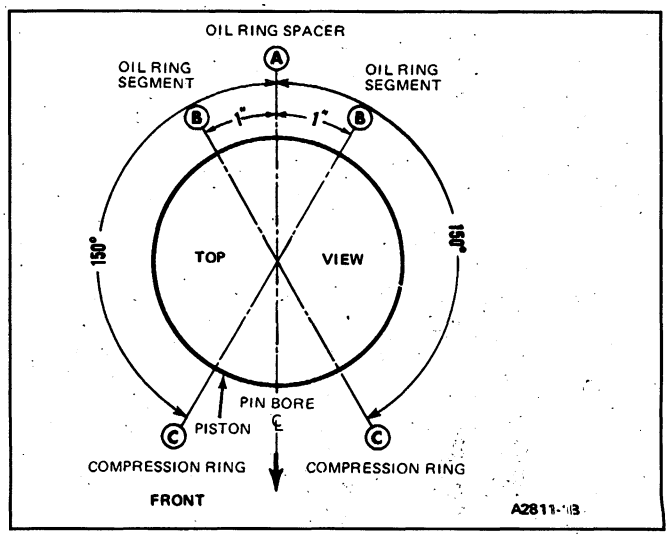


FIG. 40 Piston Ring Spacing

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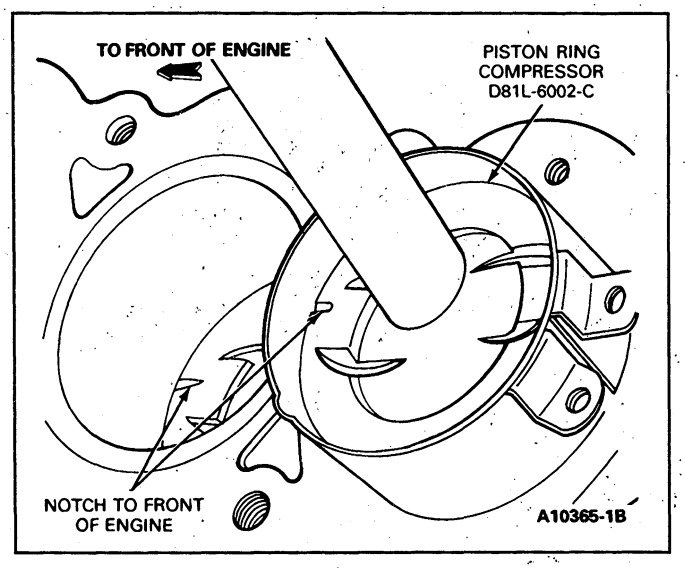


FIG. 41 Installing Piston

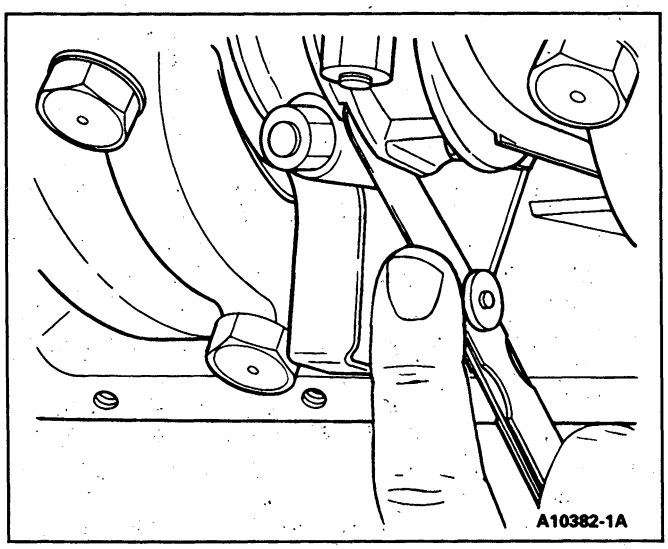


FIG. 42 Checking Connecting Rod Side Clearance

engine idle speed and idle fuel mixture to specifications on engine decal.

18. Install the air cleaner and intake duct assembly, including the crankcase ventilation hose.

Crankshaft

The crankshaft and related parts are shown in (Fig. 43).

Removal

1. With the engine removed from the vehicle and placed in a work stand, disconnect the spark plug wires at the spark plugs and remove the wires and bracket assembly from the attaching stud on the valve rocker arm covers using Spark Plug Wire Remover T74P-6666-A or equivalent (Fig. 17). Disconnect the coil to distributor high-tension lead at the coil. Remove the distributor cap and spark plug wires as an assembly. Remove the spark plugs to allow easy rotation of the crankshaft.
2. Remove the oil filter. Slide the water pump bypass hose clamp toward the water pump. Remove the alternator and mounting brackets.
3. Remove the crankshaft pulley from the crankshaft vibration damper. Remove the capscrew and washer from the end of the crankshaft. Install the puller using Crankshaft Damper Remover T58P-6316-D or equivalent on the crankshaft vibration damper (Figs. 24 or 44) and remove the damper.
4. Remove the cylinder front cover and water pump as an assembly.
5. Check the timing chain deflection. Refer to Section 21-01, General Gasoline Engine Service. Then, remove the timing chain and sprockets by following procedure under Cylinder Front Cover and Timing Chain Removal.
6. Invert the engine on the work stand. Remove the clutch pressure plate and disc (manual-shift transmission). Remove the flywheel and engine rear cover plate. Remove the oil pan and gasket. Remove the oil pump.
7. **Ensure all bearing caps (main and connecting rod) are marked so that they can be installed in their original locations.** Turn the crankshaft until the connecting rod from which the cap is being removed is down, and remove the bearing cap. Push the connecting rod and piston assembly up into the cylinder. Repeat this procedure until all the connecting rod bearing caps are removed.
8. Remove the main bearing caps.
9. Carefully lift the crankshaft out of the block so that the thrust bearing surfaces are not damaged. **Handle the crankshaft with care to avoid possible fracture or damage to the finished surfaces.**

To refinish journals and dress minor imperfections, refer to Section 21-01, General Gasoline Engine Service.

Installation

1. Remove rear journal oil seal from the block and rear main bearing cap.
2. Remove the main bearing inserts from the block and bearing caps.
3. Remove the connecting rod bearing inserts from the connecting rods and caps.
4. If the crankshaft main bearing journals have been refinished to a definite undersize, install the correct undersize bearings. Be sure the bearing inserts and bearing bores are clean. Foreign material under the inserts will distort the bearing and cause a failure.
5. Place the upper main bearing inserts in position in bores with the tang fitting in the slot provided.
6. Install the lower main bearing inserts in the bearing caps.
7. Clean the rear journal oil seal groove and the mating surfaces of the block and rear main bearing cap with Ford Spot Remover B7A-19521-A or equivalent. Refer to Section 21-01, General Gasoline Engine Service for seal replacement.
8. Carefully lower the crankshaft into place. **Be careful not to damage the bearing surfaces.**
9. Check the clearance of each main bearing. Refer to Fitting Main and Connecting Rod Bearings in Section 21-01, General Gasoline Engine Service.

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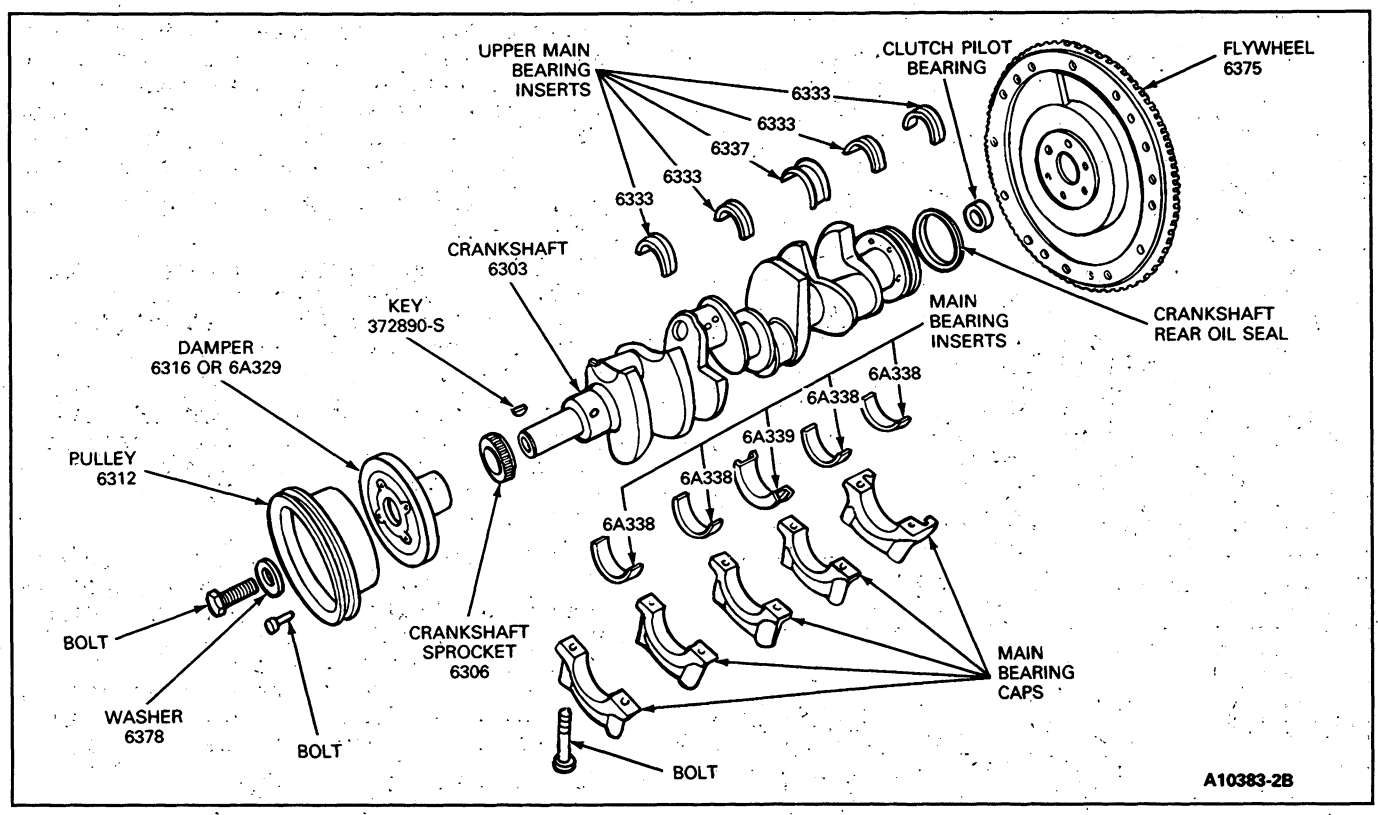


FIG. 43 Crankshaft and Related Parts

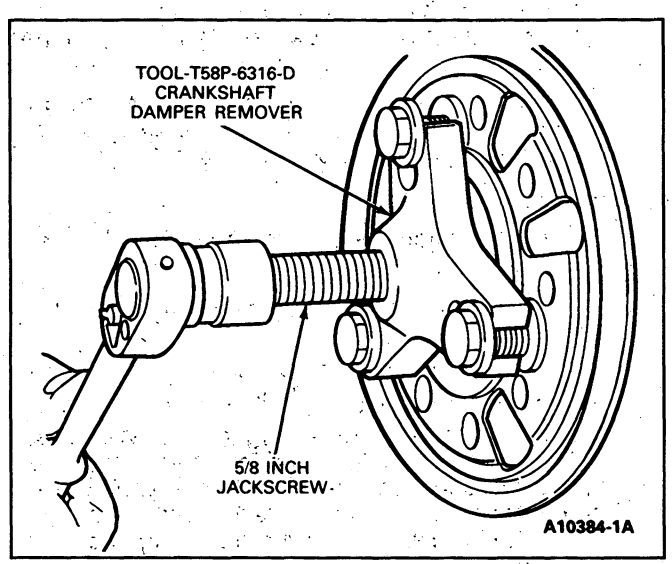


FIG. 44 Crankshaft Vibration Damper Removal—E-150—E-350

10. After the bearings have been fitted, refer to Section 21-01 for special instructions in applying RTV Sealer D6AZ-19562-B or equivalent to the rear main bearing cap.

11. Apply engine oil of the quality recommended in the Owner's Manual to the journals and bearings.

12. Install all the bearing caps, except the thrust bearing cap (No. 3 bearing). **Be sure that the main bearing caps are installed in their original locations.** Tighten the bearing cap bolts on 5.0L EFI (302 CID) V-8 to 82-94 N·m (60-70 ft-lb); on 5.8L EFI (351 CID) W-V-8 to 129-142 N·m (95-105 ft-lb).

13. Install the thrust bearing cap with the bolts finger-tight.

14. Pry the crankshaft forward against the thrust surface of the upper half of the bearing (Fig. 38).

15. Hold the crankshaft forward and pry the thrust bearing cap to the rear. This will align the thrust surfaces of both halves of the bearing.

16. Retain the forward pressure on the crankshaft. Tighten the cap bolts on 5.0L EFI (302 CID) V-8 to 82-94 N·m (60-70 ft-lb); on 5.8L EFI (351 CID) W-V-8 to 129-142 N·m (95-105 ft-lb).

17. Force the crankshaft toward the rear of the engine.

18. Check the crankshaft end play. Refer to Section 21-01, General Gasoline Engine Service.

19. Install new bearing inserts in the connecting rods and caps. Check the clearance of each bearing. Refer to Fitting Main and Connecting Rod Bearings in Section 21-01, General Gasoline Engine Service.

20. After the connecting rod bearings have been fitted, apply a light coat of recommended quality engine oil to the journals and bearings.

21. Turn the crankshaft throw to the bottom of its stroke. Push the piston all the way down until the rod bearing seats on the crankshaft journal.

22. Install the connecting rod cap. Tighten the nuts on 5.0L EFI (302 CID) V-8 to 26-32 N·m (19-24 ft-lb); on 5.8L EFI (351 CID) W-V-8 to 55-61 N·m (40-45 ft-lb).

23. After the piston and connecting rod assemblies have been installed, check the side clearance

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between the connecting rods on each connecting rod crankshaft journal (Fig. 42). Refer to Specifications.

24. Install the timing chain and sprockets, cylinder front cover and crankshaft pulley and adapter following Cylinder Front Cover and Timing Chain Installation procedure.
25. Coat the threads of the flywheel attaching bolts with oil-resistant Threadlock and Sealer E0AZ-19554-A or equivalent. Position the flywheel on the crankshaft flange. Install and tighten the bolts to 102-115 N·m (75-85 ft-lb).

    On a flywheel for manual-shift transmission, use Clutch Housing Alignment Tool T75L-6392-A or equivalent to locate the clutch disc. Install the pressure plate. Tighten the attaching bolts to 102-115 N·m (75-85 ft-lb).
26. Clean the oil pan, oil pump and oil pump screen. Prime the oil pump by filling the inlet port with engine oil and rotating the pump shaft to distribute oil within the housing. Install the oil pump and oil pan by following the procedures under Oil Pan and Oil Pump Installation.
27. Install the oil filter, fuel pump and connect the fuel lines. Install the alternator, shield and mounting bracket.
28. Install the spark plugs, distributor cap and spark plug wires. Connect the spark plug wires and high-tension lead.
29. Install the engine in the vehicle.

Camshaft Bearings

Camshaft bearings are available prefinished to size for standard and 0.38mm (0.015 inch) undersize journal diameters. The bearings are not interchangeable from one bore to another.

Removal

1. Remove the camshaft, flywheel and crankshaft as outlined. Push the pistons to the top of the cylinders.
2. Select the proper size expanding collet and backup nut and assemble on the expanding mandrel Camshaft Bearing Set T65L-6250-A or equivalent (Fig. 45). With the expanding collet collapsed, install the collet assembly in the camshaft bearing, and tighten the backup nut on the expanding mandrel until the collet fits the camshaft bearing.
3. Assemble the puller screw and extension (if necessary) and install on the expanding mandrel. Wrap a cloth around the threads of the puller screw to protect the front bearing or journal. Tighten the pulling nut against the thrust bearing and pulling plate to remove the camshaft bearing. Be sure to hold a wrench on the end of the puller screw to prevent it from turning.
4. Repeat the procedure for each bearing. To remove the front bearing, install the puller screw from the rear of the cylinder block.

Installation

1. Position the new bearings at the bearing bores with the oil holes aligned and press them in place with the Camshaft Bearing Set T65L-6250-A or equivalent (Fig. 45). Be sure to center the pulling plate and puller screw to avoid damage to the bearing. Failure to use the correct expanding collet can cause severe bearing damage. Ensure the front bearing is installed 0.127-0.508mm (0.005-0.020 inches) below the front face of the cylinder block (Fig. 46).
2. Install a new rear bearing bore plug.
3. Install the camshaft, crankshaft, flywheel and related parts as outlined. Do not check connecting rod and main bearing clearances as a part of Camshaft Bearing Replacement. Install the engine in the vehicle.

Oil Filter

The oil filter assembly is shown in Fig. 47.

Removal

1. Position a drip pan under the oil filter.
2. Unscrew the filter from the adapter fitting using an oil filter wrench D79L-6731-A or B or equivalent and clean the adapter fitting.

On E-150—E-350 equipped with power steering, ensure the wheels are fully to the right before removing the filter. Then, unscrew the filter from

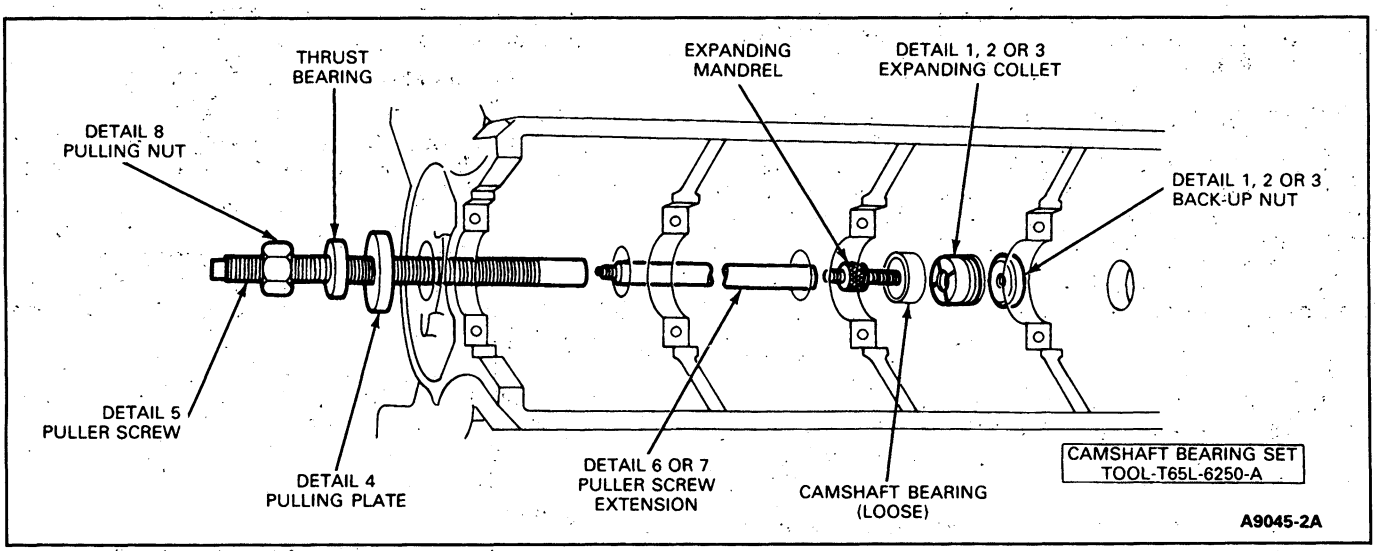


FIG. 45 Camshaft Bearing Replacement

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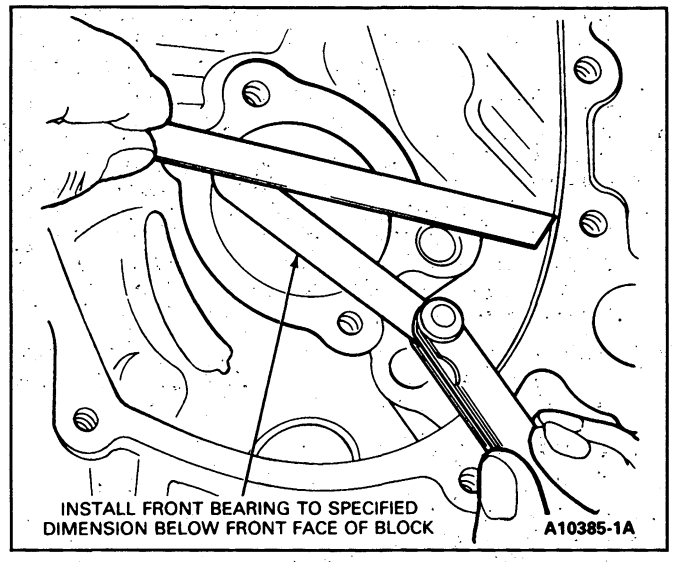


FIG. 46 Camshaft Front Bearing Replacement

the adapter fitting, turn it horizontal and let the excess oil drain off. Slide the oil filter toward the rear of the vehicle and remove (Fig. 47). Some effort may be required to slide the oil filter between the engine crossmember and power steering hoses.

Installation

1. Coat the gasket on a new filter with recommended quality engine oil. Place the new filter in position on the adapter fitting.

   On E-150—E-350 equipped with power steering, make sure that the wheels are turned fully to the right, then slide the oil filter forward between the crossmember and power steering hoses to position it on the adapter fitting.
2. Hand tighten the filter until the gasket makes contact and then advance it one-half turn.
3. Check the oil level and fill the crankcase with engine oil of the quality recommended in the Owner's Manual as necessary.
4. Operate the engine at fast idle and check for oil leaks. If oil leaks are evident, perform the necessary repairs to correct the leakage. Remove the drip pan.

DISASSEMBLY AND ASSEMBLY

When installing nuts or bolts that must be tightened (refer to specifications), oil the threads with lightweight engine oil. **Do not oil threads that require oil-resistant or water-resistant sealer.**

Refer to Section 21-01, General Gasoline Engine Service for the cleaning and inspection procedures.

Tappet

The internal parts of each hydraulic tappet assembly are matched sets. Do not mix the parts. Keep the assemblies intact until they are to be cleaned.

Tappets should always be tested after assembly. Refer to Section 21-01, General Gasoline Engine Service.

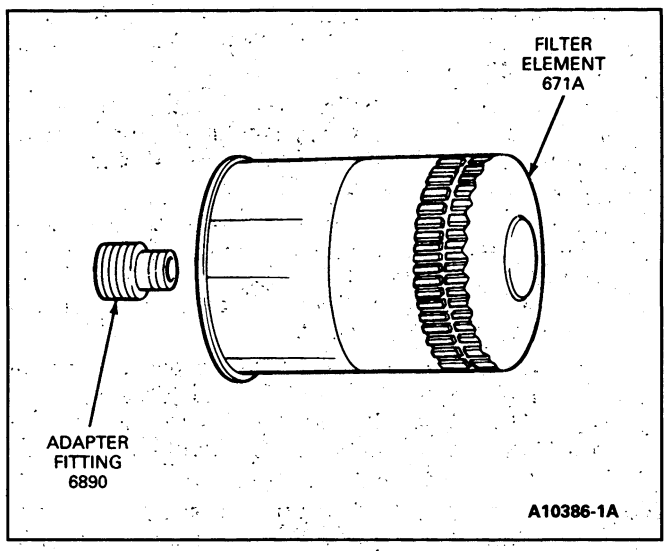


FIG. 47 Oil Filter Assembly

Disassembly

Disassemble and assemble each tappet separately. Keep the tappet assemblies in proper sequence so that they can be installed in their original bores.

1. Grasp the lock ring with needlenose pliers to release it from the groove. It may be necessary to depress the plunger to fully release the lock ring.
2. Remove the push rod cup, metering valve (disc), plunger and spring (Fig. 48).
3. Carefully remove the plunger spring, the check valve retainer and, the check valve spring and valve from the plunger.

Assembly

Tappet assembly is shown in Fig. 48.

1. Place the plunger upside down on a clean work bench.
2. Place the check valve (disc or ball check) in position over the oil hole on the bottom of the plunger. Set the check valve spring on top of the check valve (disc or ball check).
3. Position the check valve retainer over the check valve and spring and push the retainer down into place on the plunger.
4. Place the plunger spring, and then the plunger (open end up) into the tappet body.
5. Position the metering valve (disc) in the plunger, and then place the push rod cup in the plunger.
6. Depress the plunger, and position the closed end of the lock ring in the groove of the tappet body. With the plunger still depressed, position the open ends of the lock ring in the groove. Release the plunger, and then depress it again to fully seat the lock ring.
7. Use the tappet leakdown tester to fill the tappets with test fluid. Refer to Section 21-01, General Gasoline Engine Service.

Cylinder Heads

Disassembly

1. Remove the exhaust manifolds and the spark plugs.

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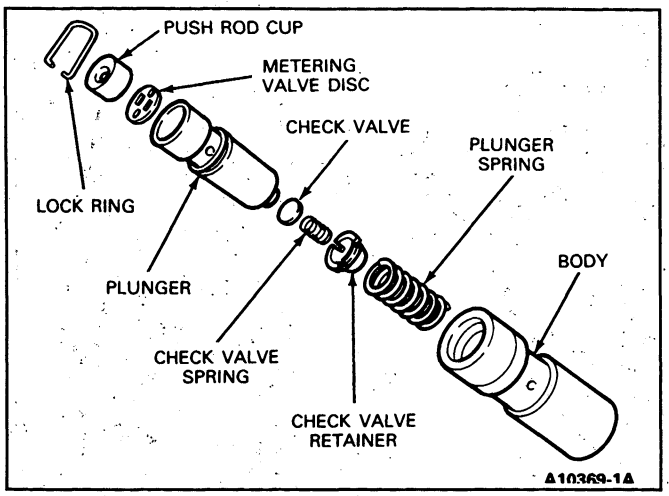


FIG. 48 Tappet Assembly

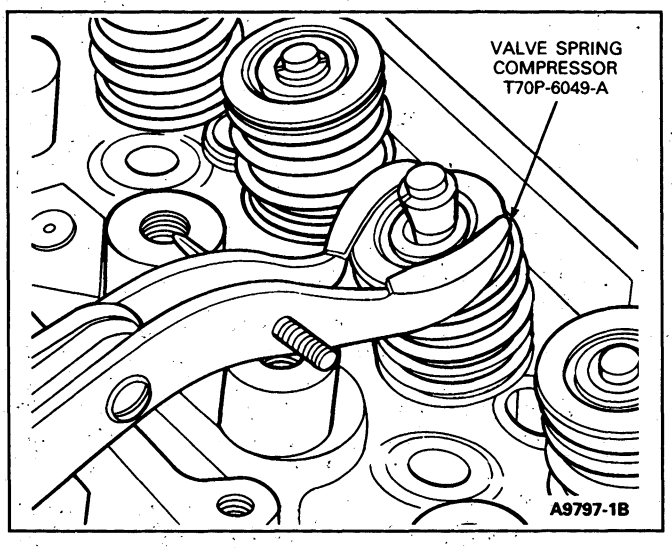


FIG. 49 Compressing Valve Spring On Bench

2. Clean the carbon out of the cylinder head combustion chambers before removing the valves.
3. Compress the valve spring using Valve Spring Compressor T70P-6049-A or equivalent (Fig. 48). Remove the spring retainer locks and release the spring.
4. Remove the sleeve, spring retainer, spring, guide mounted stem seal and valve. Discard the valve stem seals. Identify all valve parts (Fig. 50).
5. Clean, inspect and repair the cylinder head as required, or transfer all usable parts to a new cylinder head.

Assembly

1. Install each valve in the port from which it was removed or to which it was fitted. Install a new stem seal on the intake valve guide and exhaust valve guide (Fig. 18).
2. Install the valve spring over the valve, and then install the spring retainer and sleeve. Compress the spring using Valve Spring Compressor T70P-6049-A or equivalent (Fig. 49) and install the retainer locks (Fig. 50).
3. Measure the assembled height of the valve spring from the surface of the cylinder head spring pad to the underside of the spring retainer with dividers (Fig. 51). Check the dividers against a scale. If the assembled height is greater than specifications, install the necessary 0.762mm (0.030-inch) thick spacer(s) between the cylinder head spring pad and the valve spring to bring the assembled height to the recommended height.

   Do not install the spacers unless necessary. Use of spacers in excess of recommendations will result in overstressing the valve springs and overloading the camshaft lobes which could lead to spring breakage and worn camshaft lobes.

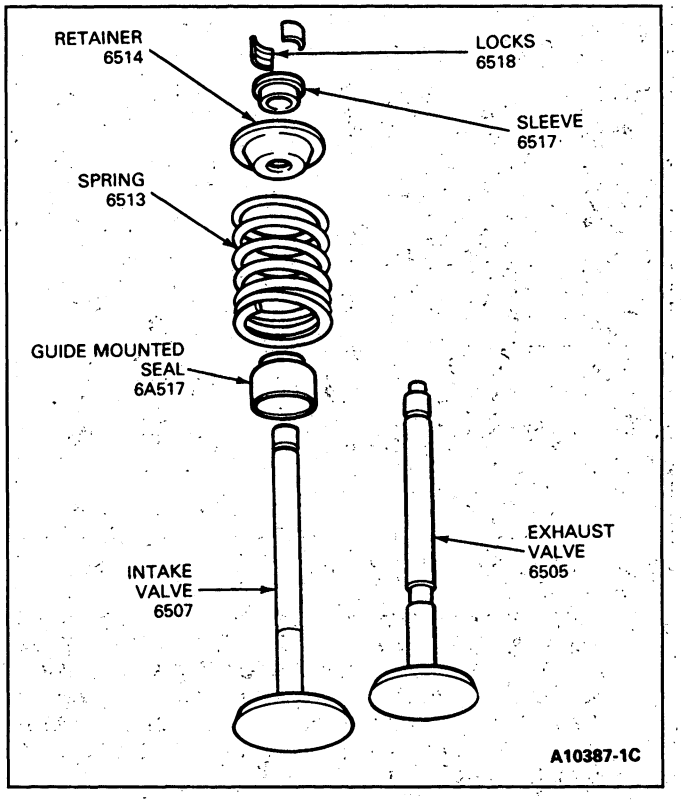


FIG. 50 Valve Assembly

4. Install the exhaust manifolds and the spark plugs.

Oil Pump

Disassembly

1. Remove the oil inlet tube from the oil pump and remove the gaskets.
2. Remove the cover attaching bolts, then remove the cover. Remove the inner rotor and shaft assembly. Then remove the outer race.
3. Drill a small hole and insert a self-threading sheet metal screw of the proper diameter into the oil pressure relief valve chamber cap and pull the cap out of the chamber. Remove the spring and plunger.

Assembly

The oil pump assembly is shown in Fig. 52.

1. Clean, inspect and oil all parts thoroughly.
2. Install the oil pressure relief valve plunger, spring and a new cap.

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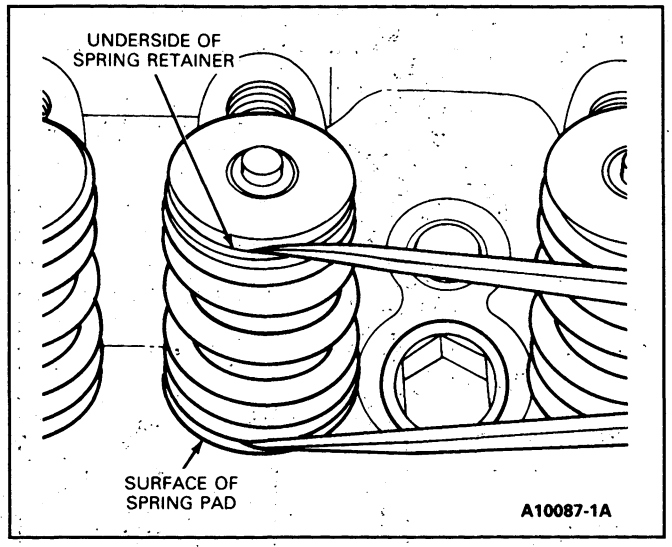


FIG. 51 Checking Valve Spring Assembled Height

3. Install the outer race and the inner rotor and shaft assembly. **Be sure the dimple (identification mark) on the outer race is facing the same side as the identification mark on the rotor.** NOTE: The entire oil pump is serviced as an assembly. Install the cover and tighten the cover attaching bolts to 30-43 N·m (22-32 ft-lb).

Pistons and Connecting Rods

Disassembly

1. Remove the bearing inserts from the connecting rod and cap.
2. Mark the pistons to ensure assembly with the same rod and installation in the same cylinders from which they were removed.
3. Using an arbor press and the Piston Pin Remover/Replacer T68P-6135-A or equivalent (Fig. 53) press the piston pin from the piston and connecting rod. Remove the piston rings if they are to be replaced.

Assembly

The piston, connecting rod and related parts are shown in Fig. 54. Check the fit of a new piston in the cylinder bore before assembling the piston and piston pin to the connecting rod.

The piston pin bore of a connecting rod and the diameter of the piston pin must be within specifications.

1. Apply a light coat of recommended quality engine oil SF to all parts. **Assemble the piston to the connecting rod with the indentation in the piston positioned as shown in Fig. 55.**

   On replacement connecting rods, install the large-chamfered side of the connecting rod bearing bore toward the crankshaft cheek; facing toward front of engine on the RH bank rods, and facing toward rear of engine on LH bank rods.
2. Start the piston pin in the piston and connecting rod (this may require a very light tap with a mallet). Using an arbor press and Piston Pin Remover/Replacer T68P-6135-A or equivalent, press the piston pin through the piston and connecting rod until the pin is centered in the piston (Fig. 53).

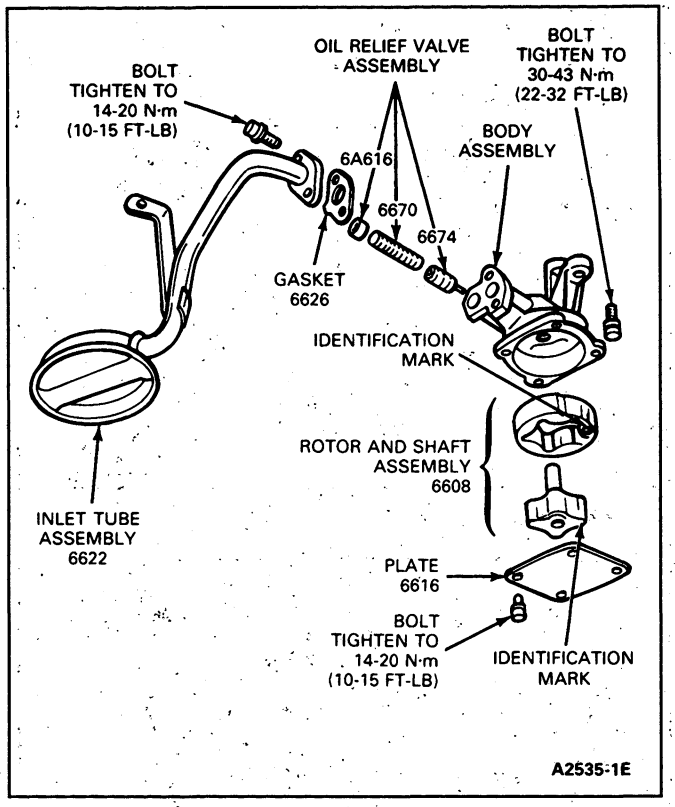


FIG. 52 Oil Pump—Disassembled

3. Check the end gap of all piston rings. Refer to Section 21-01, General Gasoline Engine Service. It must be within specifications. Follow the instructions contained on the piston ring package and install the piston rings using a piston ring installation tool of the proper size.
4. Check the ring side clearance of the compression rings with a feeler gauge inserted between the ring and its lower land. Refer to Section 21-01, General Gasoline Engine Service. The gauge should slide freely around the entire ring circumference without binding. Any wear that occurs will form a step at the inner portion of the lower land. **If the lower lands have high steps, the piston should be replaced.**
5. Ensure the bearing inserts and the bearing bore in the connecting rod and cap are clean. Foreign material under the inserts will distort the bearing and cause a failure. Install the bearing inserts in the connecting rod and cap with the tangs fitting in the slots provided.

Cylinder Block Assembly—(6009)

Disassembly

1. Mount the old engine in a work stand and remove all parts not furnished with the new cylinder block assembly following Engine Components Removal and Installation procedures.
2. Remove the old cylinder block assembly from the work stand.

Assembly

1. Clean the gasket and seal surfaces of all serviceable parts and assemblies.

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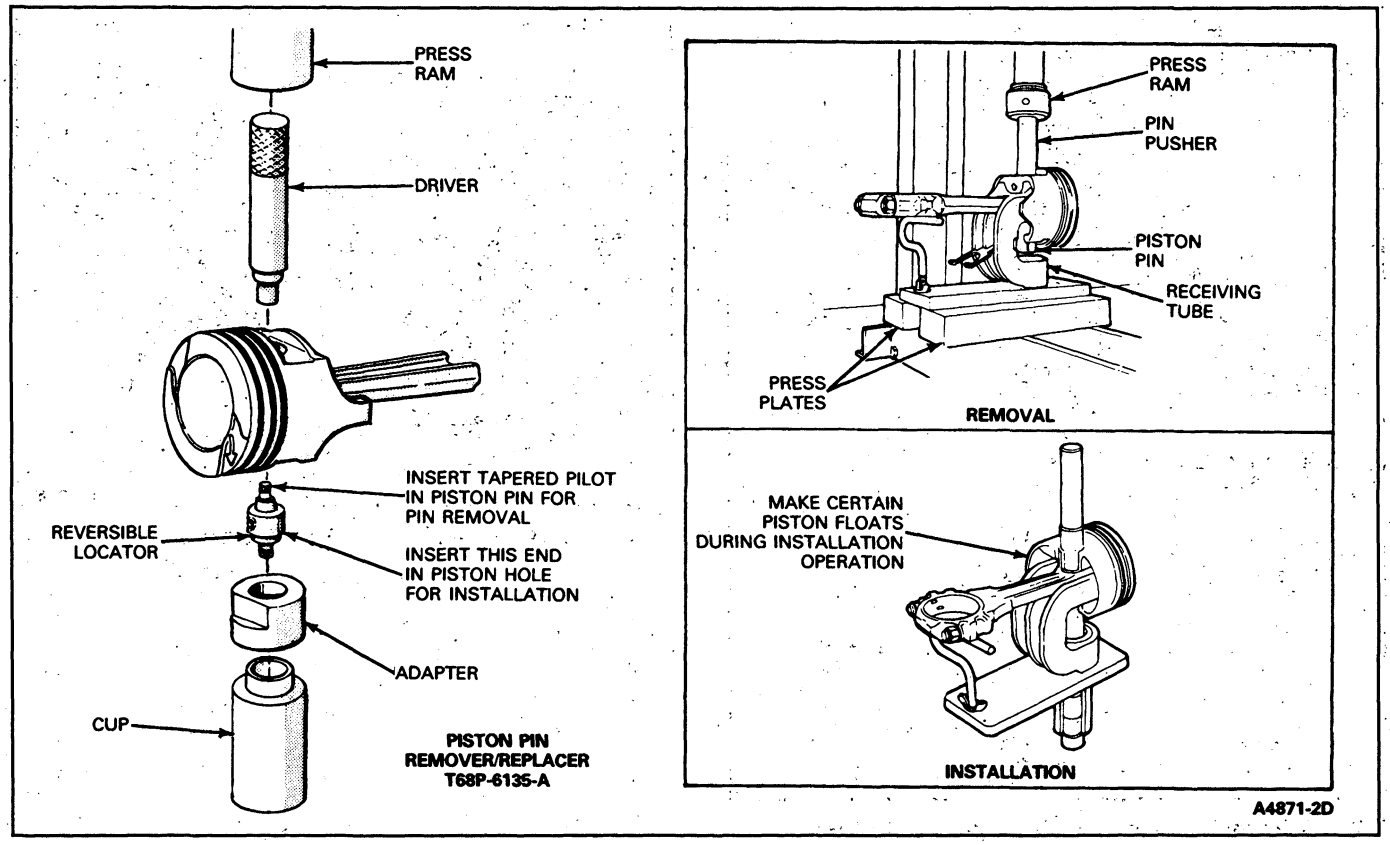


FIG. 53 Removing or Installing Piston Pin

2. Position the new cylinder block assembly in a work stand.
3. Transfer all serviceable parts removed from the old cylinder block assembly following Engine Components Removal and Installation procedures.
4. Check all assembly clearances following Specifications listed at the end of this Section, and correct as necessary.

Cylinder Block—(6010)

Before replacing a cylinder block, determine if it is repairable. If so, make the necessary repairs. Refer to Section 21-01, General Gasoline Engine Service.

Disassembly

1. Completely disassemble the old engine following Engine Components Removal and Installation procedures.
2. Remember to ridge-ream the cylinder bores before removing piston assemblies.

Assembly

1. Clean the gasket and seal surfaces of all serviceable parts and assemblies.
2. Position the new cylinder block in a work stand.
3. Transfer all serviceable parts removed from the old cylinder block following Engine Components Removal and Installation procedures.
4. Check all assembly clearances. Refer to Specifications and correct as necessary.

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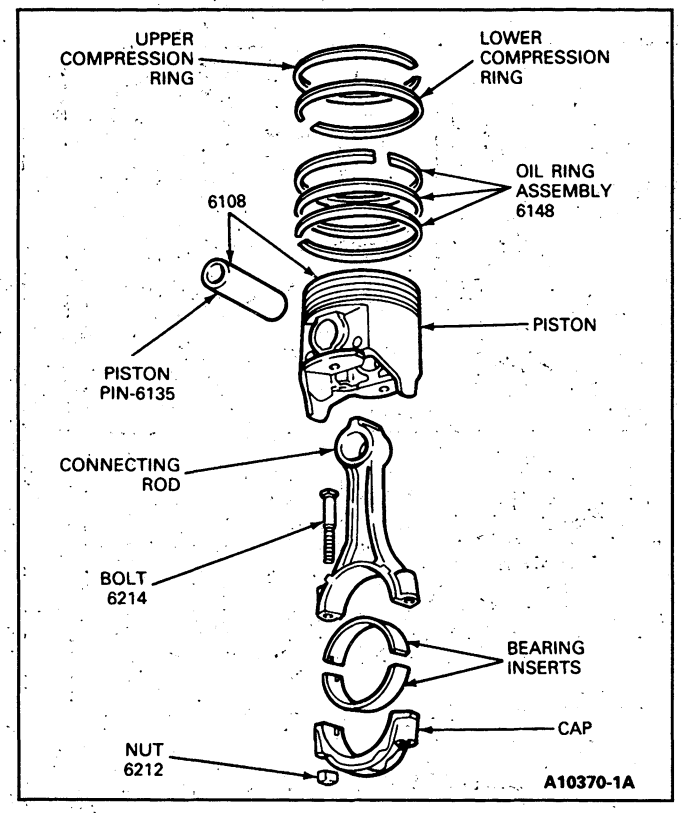


FIG. 54 Piston, Connecting Rod and Related Parts

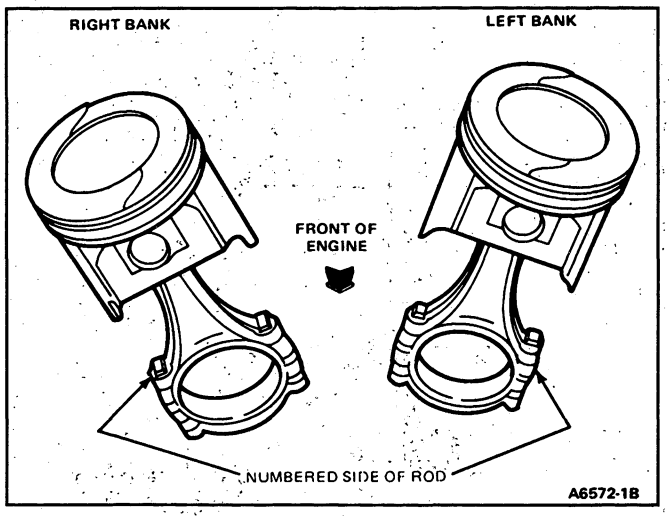


FIG. 55 Correct Piston and Rod Positions

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SPECIFICATIONS

GENERAL SPECIFICATIONS

Engine	Bore and Stroke	Firing Order	Oil Pressure Hot @ 20000 RPM		Engine Type and Number of Cylinders
			kPa	(PSI)	
5.0L (302 CID) EFI V-8	4.00 x 3.00	15426378	275-413	(40-60)	O.H.V. V-8
5.8L (351 CID) EFI W-V-8	4.00 x 3.50	13726548	275-448	(40-65)	O.H.V. V-8

CYLINDER HEAD

Engine	Combustion Chamber Volume C.C.③	Valve Guide Bore Diameter		Valve Seat Width①		Valve Seat Runout TIR Maximum	Valve Arrangement Front to Rear	Gasket Surface Flatness ②
		Intake	Exhaust	Intake	Exhaust			
5.0L (302 CID) EFI V-8 5.8L (351 CID) EFI W-V-8	60.6-63.6	.3433-.3443	.3433-.3443	.060-.080	.060-.080	.002	RT I-E-I-E-I-E-I-E LT E-I-E-I-E-I-E-I	.003 in any 6 in. .006 overall

①Valve seat angle — 45°.
②Gasket surface finish — RMS 60-150.
③Compression pressure (PSI) of the lowest cylinder must be at least 75-1/2 of the highest to be within specification.

VALVE ROCKER ARM SHAFT, PUSH RODS AND TAPPETS

Engine	Rocker Arm Lift Ratio to 1	Push Rod Runout TIR Maximum	Valve Tappet or Lifter			Collapsed Tapped Gap (Clearance)	
			Standard Diameter	Clearance to Bore ①	Hydraulic Lifter Leakdown Rate ②	Allowable	Desired
5.0L (302 CID) EFI V-8	1.61	.015	.8740-.8745	.0007-.0027	10 to 50 seconds for 1/16 travel	.071-.193	.096-.165
5.8L (351 CID) EFI W-V-8	1.61	.015	.8740-.8745	.0007-.0027	10 to 50 seconds for 1/16 travel	.098-.198	.123-.173

①Service limit .005.
②Time required for plunger to leakdown .0625 in. under load of 50 lbs. using leakdown fluid in tappet.

VALVE SPRINGS

Engine	Valve Spring Compression Pressure (lbs) @ Specified height		Valve Spring Free Length (Approximate)		Valve Spring Assembled Height		Valve Spring Out of Square
	Intake ①	Exhaust	Intake	Exhaust	Intake	Exhaust	Maximum
5.0L (302 CID) EFI V-8	74-82 @ 1.78 196-212 @ 1.36	76-84 @ 1.60 190-210 @ 1.20	2.04	1.85	1-43/64—1-45.64	1-37/64—1-39/64	5/64 (.078)
5.8L (351 CID) EFI W-V-8	74-82 @ 1.78 190-210 @ 1.20	76-84 @ 1.60 190-10 @ 1.20	2.04	1.85	1-49/64—1-51/64	1-37/64—1-39/64	5/64 (.078)

①Service limit — 10% loss pressure.

VALVES

Engine	Valve Stem to Guide Clearance①		Valve Head Diameter②		Valve Face Runout Maximum
	Intake	Exhaust	Intake	Exhaust	
5.0L (302 CID) EFI V-8	.0010-.0027	.0015-.0032	1.690-1.694 1.770-1.794	1.439-1.463	.002
5.8L (351 CID) EFI W-V-8				1.453-1.468	

①Service clearance — .0055.
②Valve face angle — 44°.

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VALVES (Continued)

Engine	Valve Stem Diameter					
	Standard		.015 Oversize		.030 Oversize	
	Intake	Exhaust	Intake	Exhaust	Intake	Exhaust
5.0L (302 CID) EFI V-8 5.8L (351 CID) EFI W-V-8	.3416-.3423	.3411-.3418	.3566-.3573	.3561-.3568	.3716-.3723	.3711-.3718

CAMSHAFT

Engine	Lobe Lift ①		Camshaft End Play		Camshaft Journal to Bearing Clearance ②
	Intake	Exhaust	End Play	Wear Limit	
5.0L (302 CID) EFI V-8	.2375	.2474	.001-.007	.009	.001-.003
5.8L (351 CID) EFI W-V-8	.2780	.2830	.001-.007	.009	.001-.003

①Maximum allowable lift loss — .005.
②Service limit — .006 maximum.

CAMSHAFT DRIVE

Engine	Camshaft Journal Diameter — Standard①					Camshaft Bearing Inside Diameter					Camshaft Front Bearing	Timing Chain Deflection Inches Maximum
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 1	No. 2	No. 3	No. 4	No. 5	Location②	
5.0L (302 CID) EFI V-8	2.0805-	2.0655-	2.0505-	2.0355-	2.0205-	2.0825-	2.0675-	2.0525-	2.0375-	2.0225-	.005-.020	.500
5.8L (351 CID) EFI W-V-8	2.0815	2.0665	2.0515	2.0365	2.0215	2.0835	2.0685	2.0535	2.0385	2.0235		

①Camshaft journal runout — .005 TIR maximum.
②Distance in inches that front edge of the bearing is installed below the front face of the cylinder block.

CYLINDER BLOCK

Engine	Cylinder Bore Diameter①	Main Bearing Bore Diameter②	Distributor Shaft Bearing Bore Diameter	Head Gasket Surface Flatness	Head Gasket Surface Finish	Tappet Bore Diameter
5.0L (302 CID) EFI V-8	4.0004-4.0052	2.4412-2.4420	.4525-.4541	.003 in any 6 in. .006 overall	RMS 60-150	.8752-.8767
5.8L (351 CID) EFI W-V-8	4.0000-4.0048	3.1922-3.1930	.5155-.5170	.003 in any 6 in. .006 overall	RMS 60-150	.8752-.8767

①Maximum out-of-round — .0015, Service limit — .005, Maximum taper service limit — .010, Cylinder bore surface finish — RMS 18-38, Bore tapes service limit — .010.
②Crankshaft to rear face of block runout. TIR maximum .005.

CRANKSHAFT AND FLYWHEEL

Engine	Main Bearing Journal Diameter①	Main Bearing Journal Runout TIR Maximum②	Main Bearing Thrust Face Runout TIR Maximum	Main Bearing Journal Taper Maximum Per Inch	Thrust Bearing Journal Length	Main and Rod Bearing Journal Finish RMS Maximum	Main Bearing Thrust Face Finish RMS Maximum
5.0L (302 CID) EFI V-8	2.2482-2.2490	.002	.001	.0005	1.137-1.139	12	25 Front— 20 Rear
5.8L (351 CID) EFI W-V-8	2.9994-3.0002	.002	.001	.0005	1.137-1.139	12	25 Front— 20 Rear

①Maximum out-of-round — .0006.
②Service limit — .005.

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CRANKSHAFT AND FLYWHEEL (Continued)

Engine Assembled	Connecting Rod Journal Diameter①	Connecting Rod Journal Taper Per Inch Maximum	Crankshaft Free End Play②	Flywheel Clutch Face Run-Out
5.0L (302 CID) EFI V-8	2.1228-2.1236	.0006	.004-.008	0.010
5.8L (351 CID) EFI W-V-8	2.3103-2.3111	.0006	.004-.008	0.010

①Maximum out-of-round — .0006.
②Service limit — .012.

CRANKSHAFT BEARINGS

Engine	Connecting Rod Bearing To Crankshaft Clearance Selective Fit			Main Bearing to Crankshaft Clearance Selective Fit		
	Desired	Allowable	Bearing Wall Thickness Std.①	Desired	Allowable	Bearing Wall Thickness Std.①
5.0L (302 CID) EFI V-8	.0008-.0015	.0007-.0024	.0572-.0577	②	③	④
5.8L (351 CID) EFI W-V-8	.0008-.0015	.0008-.0025	.0572-.0577	.0008-.0015	.0008-.0026	.0957-.0960

①For .002 undersize add .001 to standard wall thickness.
②#1 Bearing — .0001-.0015. All others — .0005-.0015.
③#1 Bearing — .0001-.0020. All others — .0005-.0024.
④#1 Upper only .0961 — .0966. All others .0957-.0962.

CONNECTING ROD

Engine	Piston Pin Bore or Bushing I.D.	Rod Bearing Bore I.D.①	Rod Length Center to Center	Connecting Rod Alignment Maximum Total Difference		Rod To Crankshaft Assembled Side Clearance③
				Twist③	Bend②	
5.0L (302 CID) EFI V-8	.9096-.9112	2.2390-2.2398	5.0885-5.0915	.024	.012	.010-.020
5.8L (351 CID) EFI W-V-8	.9097-.9112	2.4265-2.4273	5.9545-5.9575	.024	.012	.010-.020

①Connecting rod bearing bore maximum out-of-round — .0004
②Pin bushing and crankshaft bore must be parallel and in same vertical plane with specified total difference when measured at the ends of an 8-inch long bar, 4 inches on each side of rod centerline.
③Service limit — .023

PISTON

Engine	Diameter①			Piston to Bore Clearance Selective Fit	Piston Pin Bore Diameter	Ring Groove Width Compression		
	Coded Red	Coded Blue	.003 Oversize			Top	Bottom	Oil
5.0L (302 CID) EFI V-8	3.9991-3.9985	3.999-4.000	4.0008-4.0014	.0013-.0030	.9123-.9126	.060-.061	.060-.061	.587-.1587
5.8L (351 CID) EFI W-V-8	3.9978-3.9984	3.9990-3.9996	4.0002-4.0008	.0018-.0026	.9124-.9127	.080-.081	.080-.081	.188-.189

①Measured at the piston pin bore centerline at 90° to the pin.

PISTON PIN

Engine	Length	Diameter			To Piston Pin Bore Clearance①	To Connecting Rod Bushing Clearance
		Standard	.001 Oversize	.002 Oversize		
5.0L (302 CID) EFI V-8	3.010-3.040	.9119-.9124	.9130-.9133	.9140-.9143	.0002-.0004	Interference Fit
5.8L (351 CID) EFI W-V-8	3.010-3.040	.9119-.9124	.9130-.9133	.9140-.9143	.0003-.0005	Interference Fit

①Selective fit.

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PISTON RINGS

Engine	Ring Width		Side Clearance①			Ring Gap		
	Top Compression	Bottom Compression	Top Compression	Bottom Compression	Oil	Top Compression	Bottom Compression	Oil②
5.0L (302 CID) EFI V-8 5.8L (351 CID) EFI W V-8	.0577-.0587	.0577-.0587	.0013-.0033	.002-.004	Snug	.010-.020 In Gage	.010-.020 In Gage	.015-.055 In Gage

①Service limit — .002 maximum increase in clearance.
②Steel rail.

OIL PUMP AND OIL CAPACITY

Engine	Relief Valve Spring Pressure Lbs. @ Specified Length	Driveshaft to Housing Clearance	Relief Valve to Housing Clearance	Rotor Assembly End Clearance	Outer Race to Housing Clearance	Engine Oil Capacity①		
						U.S. Quarts	Imperial Quarts	Litres
5.0L (302 CID) EFI V-8	10.6-12.2 @ 1.74	.0015-.0030	.0015-.0030	.004 Maximum	.001-.013	5	4.2	4.7
5.8L (351 CID) EFI V-8	18.2-20.2 @ 2.49	.0015-.0030	.0015-.0030	.004 Maximum	.001-.003	5	4.2	4.7

①Add 1 U.S. quart (or equivalent in imperial quarts or liters) when replacing filter.

FUEL PUMP — MECHANICAL

Engine	Static Pressure (PSI)①	Volume Flow — Minimum①②	Eccentric Total Lift — Inches
5.8L (351 CID) EFI W V-8	6.0-8.0	1 pint in 20 seconds	.690-.710

①On the engine with temperature normalized and at normal curb idle speed, in neutral.
②The inside diameter of the smallest passage in the test flow circuit must not be less than .220.

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TORQUE LIMITS — 5.0L (302 CID) EFI V-8 — 5.8L (351 CID) EFI W-V-8

NOTE: All values in N•m (ft-lbs), unless otherwise noted. Oil threads with engine oil unless the threads require oil or water-resistant sealer. The standard torque limits listed below are applicable for all functions not listed in the special torque chart.

1/4-20	5/16-18	5/16-24	3/8-16	3/8-24	7/16-14	7/16-20	1/2-13	9/16-18
8-12 (6-9)	17-24 (12-18)	19-27 (14-20)	30-43 (22-32)	37-51 (27-38)	61-77 (45-57)	55-81 (40-60)	75-81 (55-60)	116-162 (85-120)

PIPE THREADS

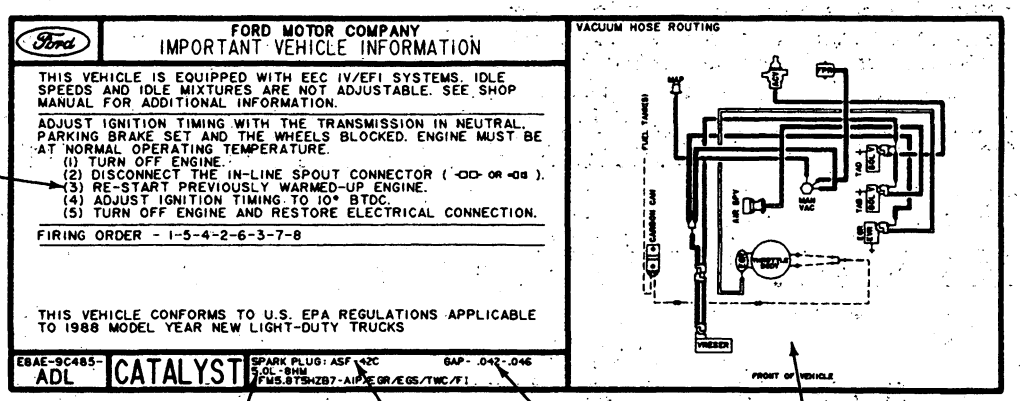
1/8-27	1/4-18	3/8-18	1/2-14
7-11 (5-8)	17-24 (12-18)	30-44 (22-33)	34-47 (25-35)

Item	Torque	
	N•m	(ft-lbs)
Camshaft Sprocket — Gear to Camshaft	55-61	(40-45)
Camshaft Thrust Plate to Cylinder Block	13-16	(9-12)
Connecting Rod Nut — 5.0L (302 CID) V-8 — 5.8L (351 CID) W-V-8	26-32 55-61	(19-24) (40-45)
Cylinder Front Cover	17-24	(12-18)
Cylinder Head Bolts	① ②	
Damper to Crankshaft	95-122	(70-90)
EGR Valve to Carburetor Spacer or Intake Manifold	17-24	(12-18)
Fuel Pump to Cylinder Block of Front Cover	26-36	(19-27)
Flywheel to Crankshaft	102-115	(75-85)
Main Bearing Cap Bolts — 5.0L (302 CID) V-8 — 5.8L (351 CID) W-V-8	82-94 129-142	(60-70) (95-105)
Manifold to Cylinder Head — Intake	32-33	(23-25)
Manifold to Cylinder Head — Exhaust	25-32	(18-24)
Intake Manifold Vacuum Fittings — Aluminum — Cast Iron	8-13 32-37	(6-10) (23-28)
Intake Manifold Pipe Fittings — Aluminum — Cast Iron	17-24 32-37	(12-18) (23-28)
Oil Inlet Tube to Main Bearing Cap	30-43	(22-32)
Thermactor Pump Bracket to Cylinder Block	44-67	(30-45)
Carburetor Mounting Stud	7-13	(5-10)
Distributor Clamp Down	24-32	(17-25)
Oil Filter Insert to Cylinder Block/Adaptor	28-40	(20-30)
Oil Filter to Adaptor or Cylinder Block	1/2 turn after gasket contacts sealing surface — oiled gasket	
Oil Inlet Tube Pump	14-20	(10-15)
Oil Pan Drain Plug	21-33	(15-25)
Oil Pan to Cylinder Block	13-14	(9-11)
Oil Pump to Cylinder Block	30-43	(22-32)
Pulley to Damper Bolt	48-67	(35-50)
Rocker Arm Stud/Bolt to Cylinder Head	25-33	(18-25)
Spark Plug to Cylinder Head	14-20	(10-15)
Valve Rocker Arm Cover	4-6	(3-5)
Water Outlet Housing	13-16	(9-12)
Water Pump to Block/Front Cover	17-24	(12-18)
Alternator Bracket to Cylinder Block — Bolt	17-24	(12-18)
Alternator Adjusting Arm to Alternator Bolt	33-60	(24-40)
Thermactor Pump Pivot Bolt	30-43	(22-32)
Thermactor Pump Adjusting Arm to Pump	30-43	(22-32)
Thermactor Pump Pulley to Pump Hub	17-24	(150-220 in-lbs)

①5.0L (302 CID) EFI V-8 — Tighten in steps: first to 75-88 N•m (55-65 ft-lbs.) then to 88-97 N•m (65-72 ft-lbs.)
②5.8L (351 CID) EFI W-V-8 — Tighten in steps: first to 115 N•m (85 ft-lbs.) then to 129 N•m (95 ft-lbs.), final to 143-151 N•m (105-112 ft-lbs).

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Tool Number	Description
D79P-100-A	Impact Slide Hammer
T50T-100-A	Impact Slide Hammer
T59L-100-B	Impact Slide Hammer
T58L-101-B	Puller Attachment
D80L-522-A	Damper Remover
TOOL-4201-C	Dial Indicator with Bracketry
T70P-6000	Engine Lifting Brackets
T75T-6000-A	Engine Lifting Plate
T64L-6011-EA	Cylinder Ridge Reamer
T73L-6011-A	Cylinder Hone Set
T61P-6019-B	Front Cover Aligner
T70P-6049-A	Valve Spring Compressor
T68P-6135-A	Piston Pin Remover/Replacer
T65L-6250-A	Camshaft Bearing Set
T52L-6306-AEE	Crankshaft Damper & Sprocket Replacer
T58P-6316-D	Crankshaft Damper Remover
T79T-6316-A	Damper Remover/Replacer Tool
TOOL-6331-E — or TOOL-6331 (351 CID)	Upper Main Bearing Insert Remover & Replacer
T74P-6375-A	Flywheel Holding Tool
T75L-6392-A	Clutch Housing Alignment Tool
TOOL-6500-E	Hydraulic Tappet Leakdown Tester
T71P-6513-B	Tappet Bleed Down Wrench
TOOL-6513-DD	Valve/Clutch Spring Tester
T70P-6049-A	Valve Spring Compressor
TOOL-6565-AB	Cup Shaped Adapter
T73L-6600-A	Pressure Gauge
D79P-6666-A	Spark Plug Boot Puller
T74P-6666-A	Spark Plug Wire Remover
D79L-6731-A	Oil Filter Wrench
D79L-6731-B	Oil Filter Wrench
T74P-7137-A	Pilot Bearing Replacer
T70P-6B070-A	Front Cover Seal Replacer
T70P-6B070-B	Front Cover Seal Remover
D81L-6002-C	Piston Ring Compressor

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ROTUNDA EQUIPMENT

Model Number	Description
066-00017	Transmission Jack

CA7334-1D

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VEHICLE APPLICATION

F-250 and F-350 and F-Super Duty Chassis Cab and Motor Home Chassis, E-250 and E-350 Models.

DESCRIPTION

Engine Code Information Label

An engine code information label located on the rocker arm cover contains an engine build date, an engine plant code and an engine code (Fig. 1).

Engine

The 7.5L (460 CID) EFI V-8 engine has a light-weight cast-iron cylinder block. The crankshaft is precision-cast, nodular iron alloy and has five main bearings. The pistons are autothermic-cast aluminum alloy, tin plated. Valve rocker arms are pedestal-mounted and the tappets are hydraulic. Large, chrome-plated intake and exhaust valves provide optimum breathing. A low restriction air cleaner is utilized for maximum clean air intake. Refer to the chart under Specifications for complete specifications.

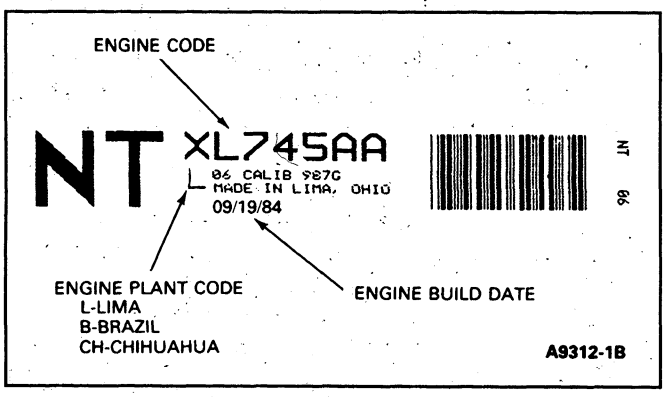


FIG. 1 7.5L Engine Code Label

The 7.5L (460 CID) EFI engine is standard equipment for F-Super Duty Motor Home Chassis vehicles.

The 7.5L (460 CID) EFI engine is optional for E-250 and E-350, and F-250 and F-350 and F-Super Duty.

Emission Calibration Label

Refer to Fig. 2.

The emission calibration number label is located on the LH side door or LH door post pillar. It identifies the engine calibration number, the engine code number and revision level.

These numbers are used to determine if parts are unique to specific engines.

NOTE: It is imperative that the engine codes and the calibration number be used when ordering parts or making inquiries about the engine.

Exhaust Emission Control System

Operation, removal, installation and required maintenance of the exhaust emission control devices

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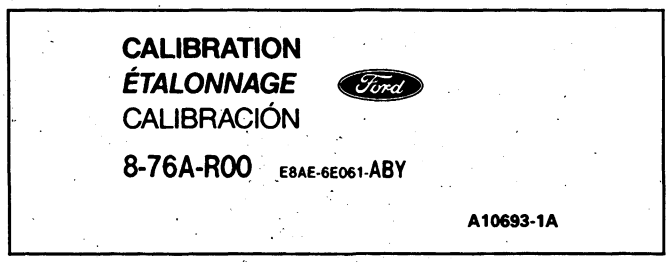


FIG. 2 Emission Calibration Label

used on the 7.5L (460 CID) EFI engine are covered in the Engine/Emissions Diagnosis* manual.

Crankcase Ventilation System

The 7.5L (460 CID) EFI V-8 engine is equipped with a positive closed-type crankcase ventilation system to purge the crankcase vapors.

Lubrication System

The heart of the lubrication system (Fig. 3) is a full-pressure cast-iron pump. The high capacity "G-rotor" pump is driven by a hex shaft from the distributor. The pressure is relief-valve controlled.

Oil is directed through drilled oil passages to the full-flow oil filter and from the filter to main oil galleries intersecting the valve guide bores. A drilled gallery (crossover) at the rear of the tappet chamber routes oil to the LH bank. The main, connecting rod, and camshaft bearings are supplied with oil from the RH oil gallery.

Oil flow to the camshaft sprocket and timing chain is through an annulus and drilled passage at the front of the No. 1 camshaft bearing. Oil flow to the rocker arms is through the tappets and up the push rods to the arms.

All vehicles are equipped with an oil cooler, mounted in front of the radiator.

Cooling System

The cooling system is a series-parallel flow design (Fig. 4). Coolant flow is from the water pump through passages in the front cover (both sides) to the cylinder block. Flow continues through the block to the rear and up through the deck or head faces. It then travels forward through the cylinder heads to the water crossover at the front of the intake manifold, through the water outlet (thermostat housing) and to the top of the radiator.

DIAGNOSIS AND TESTING

Refer to Diagnosis and Testing in Section 21-01, General Gasoline Engine Service.

ADJUSTMENTS

Valve Clearance

The valve arrangement on the LH bank is E-I-E-I-E-I-E-I and on the RH bank is I-E-I-E-I-E-I-E.

A 1.52mm (0.060-inch) shorter push rod or a 1.52mm (0.060-inch) longer push rod is available for service to provide a means of compensating for dimensional changes in the valve mechanism. Refer to the Master Parts List or the specifications for the pertinent color code.

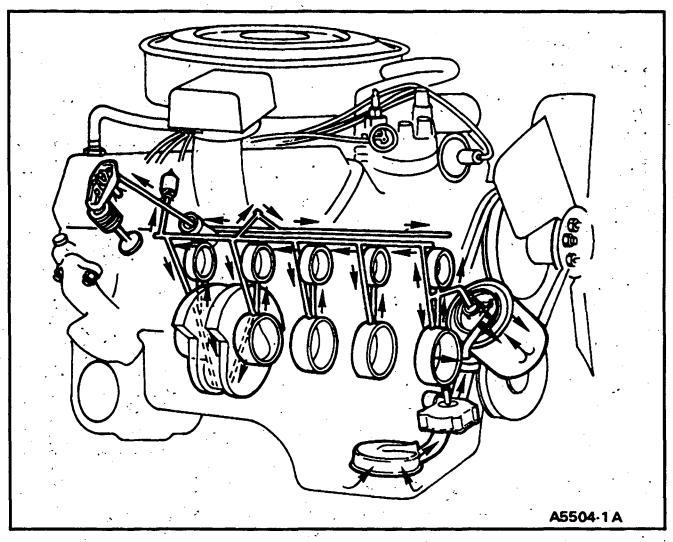


FIG. 3 Lubrication System Schematic

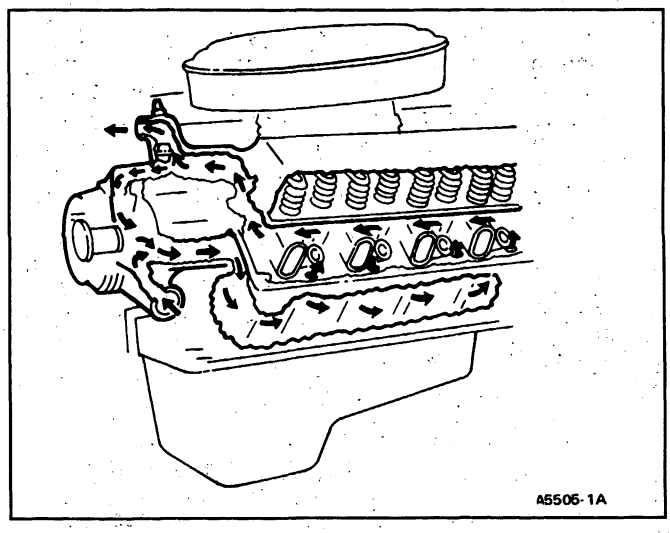


FIG. 4 Cooling System Schematic

Valve stem-to-valve rocker arm clearance should be within specifications as outlined. With the hydraulic tappet completely collapsed, repeated valve reconditioning operations (valve and/or valve seat refacing) will decrease the clearance to the point that if not compensated for, the hydraulic valve tappet will cease to function and the valve will be held open.

The use of a positive stop valve rocker arm bolt eliminates the need for valve clearance adjustment. However to obtain accurate valve clearance measurements, it is important that all components be serviceable and installed to specification.

To determine whether a shorter or a longer push rod is necessary, perform the following check:

1. Install an auxiliary starter switch. **Crank the engine with the ignition switch in OFF until the No. 1 piston is on TDC after the compression stroke.**
2. With the crankshaft in the positions designated in the following Steps 3, 4 and 5, position the hydraulic tappet compressor Tappet Bleed Down Wrench T71P-6513-B or equivalent on the rocker arm. Slowly apply pressure to bleed down the

*Can be purchased as a separate item.

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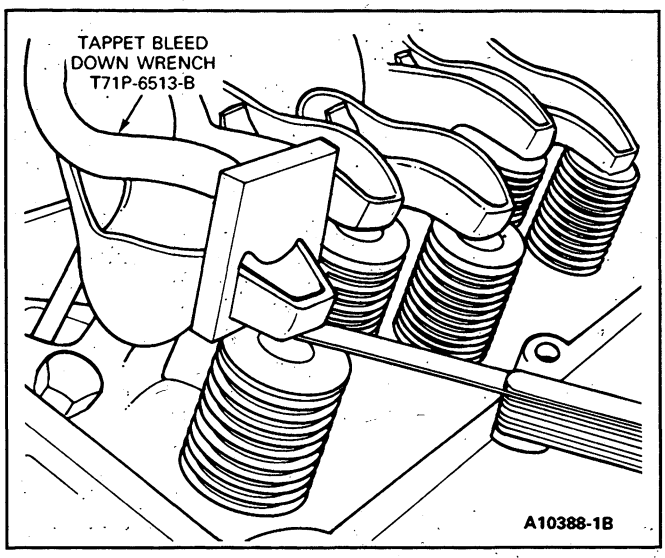


FIG. 5 Checking Valve Clearance

hydraulic tappet until the plunger is completely bottomed (Fig. 5). Hold the tappet in this position and check the available clearance between the rocker arm and the valve stem tip with a feeler gauge. If the clearance is less than specifications, install a shorter push rod. If the clearance is greater than specifications, install a longer push rod.

3. With the No. 1 piston at TDC at the end of the compression stroke as shown in POSITION NO. 1, Fig. 6, check clearances on the following valves:

   No. 1 Intake No. 1 Exhaust

   No. 3 Intake No. 4 Exhaust

   No. 7 Intake No. 5 Exhaust

   No. 8 Intake No. 8 Exhaust

4. After checking the clearance on these valves, rotate the crankshaft 360 degrees to POSITION NO. 2 as shown in Fig. 6, then check the following valves:

   No. 2 Intake No. 2 Exhaust

   No. 4 Intake No. 3 Exhaust

   No. 5 Intake No. 6 Exhaust

   No. 6 Intake No. 7 Exhaust

REMOVAL AND INSTALLATION

When installing nuts or bolts (refer to Torque Specifications listed at the end of this Section), oil the threads with lightweight engine oil. **Do not oil threads requiring oil-resistant or water-resistant sealer.**

Refer to Section 21-01, General Gasoline Engine Service, for cleaning, inspection and testing procedures.

Electronic Fuel Injection

Refer to Section 24-32 for service of EFI components.

Engine

The engine removal and installation procedures are for the engine only (without the transmission attached).

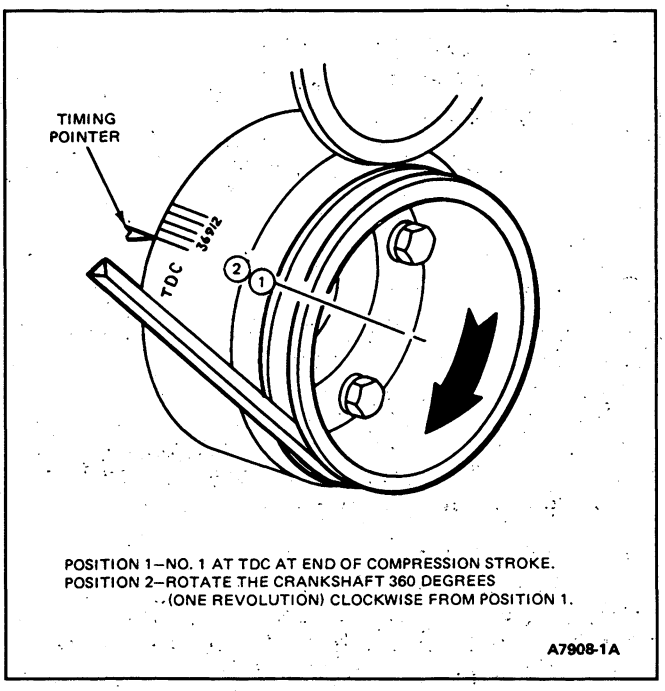


FIG. 6 Positioning Crankshaft for Checking Valve Clearance and Installing Rocker Arms

E-250—E-350

Removal

1. Remove engine cover, open the hood, disconnect battery, and drain cooling system. Refer to Section 27-02, Cooling System Service. Remove the grill assembly including gravel deflector.
2. Remove four bolts that secure the air cleaner and bracket assembly at the body cowl and radiator support.
3. Disconnect the thermactor air pump inlet hose at the front of the air cleaner housing.
4. Disconnect the air outlet tube assembly at the throttle body and upper intake manifold. The air cleaner assembly and air outlet tubes can now be removed, after disconnecting the air inlet tube at the air cleaner.
5. Remove the thermactor bypass valve hose connected to the air inlet tube and remove the air inlet tube.
6. Remove the upper grille support bracket, hood lock support and condenser upper mounting brackets.
7. If so equipped, discharge the A/C system, and remove the A/C condenser. Refer to Section 36-65, E-150—E-350 Air Conditioning System. Disconnect the A/C lines at the compressor. Remove the accelerator cable bracket from the dash. Disconnect the two heater hoses from the engine.
8. Disconnect the upper and lower radiator hoses at the radiator.
9. Disconnect the engine oil cooler lines at the oil filter adapter. Do not attempt to disconnect lines at the quick disconnect fittings at the cooler (Fig. 7). The fittings, or the cooler, may become damaged.
10. Remove the fan shroud and fan assembly (Fig. 8). Remove the radiator from the vehicle. Refer to

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Section 27-04, Radiators. Remove the A/C condenser. Refer to Group 36, Air Conditioning, in the Body, Chassis and Electrical Manual. Pivot the alternator inward. Disconnect the alternator lead wires at the alternator.

11. Disconnect throttle and transmission linkage at throttle body and remove accelerator cable bracket from upper intake manifold. Remove the speed control hardware if so equipped.
12. Disconnect the fuel lines at quick disconnect couplings and vacuum lines to the intake manifold. Disconnect EGR tube at LH exhaust manifold and upper intake manifold. Plug manifold opening. Refer to Group 24. Raise the vehicle on hoist, drain the crankcase, and remove the oil filter.
13. Disconnect the muffler inlet pipe at the exhaust manifolds. Remove two bolts retaining the transmission filler tube bracket to the RH cylinder head.
14. Disconnect exhaust air supply bypass valve hose at MTA check valve.
15. Remove the engine mount attaching bolts and nuts (Fig. 9). Remove the starter motor and disconnect the cable. Refer to Section 28-02, Positive Engagement Starter. Remove the converter inspection cover bolts.
16. Remove four nuts attaching the converter to the flex plate.
17. Remove three bolts retaining the adapter plate to the converter housing.
18. Remove four converter housing-to-cylinder block lower bolts. Remove the bolt attaching the ground cable to the cylinder block. Lower the vehicle on hoist.
19. Loosen the belt tensioner and remove the drive belt. Disconnect the A/C compressor, A/C lines and magnetic clutch lead wire, if so equipped. Disconnect power steering pump lines. Remove pump and bracket from front of engine. Remove the power steering front face bracket bolts.
20. Disconnect any vacuum lines at the rear of the intake manifold. Disconnect the engine wire loom and position it out of the way.
21. Position a floor jack under the transmission for support. Position a floor crane to the vehicle and connect it to existing lifting eyes.
22. Remove two converter housing-to-cylinder block upper bolt and remove the engine from the vehicle.

Installation

1. Connect the floor crane to lifting eyes. Raise the engine and position it into the vehicle, aligning the transmission converter to the flywheel (or flex plate) and the engine dowels to the transmission. Lower the engine to the chassis brackets, and align the through bolt holes (Fig. 9). Disconnect the floor crane and position it out of the way.
2. Install two converter housing-to-cylinder block upper bolts. Remove the lifting bracket from the intake manifold (bolts).
3. Remove floor jack from under the transmission, and position it out of the way.
4. If so equipped, connect the A/C compressor magnetic clutch lead. Refer to Section 36-65, E-150—E-350 Air Conditioning System.
5. Position the accelerator cable mounting bracket and the speed control servo to the intake manifold, and install attaching bolts.
6. Position the engine wire harness in retainers and connect at respective locations. Connect vacuum lines at the rear of the intake manifold.
7. Connect two heater hoses at water outlet connector and at water pump connector. Position the power steering front face bracket and the power steering pump to the water pump and the LH cylinder head. Install the attaching bolts.
8. Position the power steering pump drive belt to its respective pulleys, and install automatic belt tensioner. If so equipped, connect two A/C lines at the A/C compressor, and install the accelerator cable bracket to the dash. Refer to Section 36-65, E-150—E-350 Air Conditioning System.
9. Raise the vehicle on a hoist. Install one bolt attaching battery ground cable to cylinder block. Install four lower converter housing-to-cylinder block lower bolts. Install the three adapter plate-to-converter housing bolts. Install four nuts attaching the converter to the flex plate. Install the converter inspection cover (bolts).
10. Install the starter motor and connect the cable. Refer to Section 28-02, Positive Engagement Starter. Install the engine mount attaching bolts and nuts. Tighten to 68-94 N·m (50-70 ft-lb) (Fig. 9).
11. Install the two bolts attaching the transmission filler tube bracket to the RH cylinder head.
12. Connect the muffler inlet pipe at the exhaust manifolds. Install the oil filter.
13. Lower the vehicle on hoist. Position the upper intake manifold and gasket onto the lower intake manifold, install four bolts and connect the fuel lines and vacuum lines. Refer to Section 24-32, Electronic Fuel Injection—7.5L Engine.
14. Connect the throttle and transmission linkage at the throttle body. Connect the alternator lead wires to the alternator.
15. Install the fan assembly to the water pump shaft (Fig. 8) and position the shroud over the fan assembly.
16. Position the radiator to the radiator support and secure with four attaching bolts. Refer to Section 27-04, Radiators. Install the shroud and secure with four attaching bolts.
17. Connect two engine oil cooler lines at the oil filter adapter (Fig. 7).
18. Connect the radiator lower hose at the radiator. Connect the radiator upper hose at the radiator.
19. Install the A/C condenser-to-radiator support, if so equipped. Refer to Section 36-65, E-150—E-350 Air Conditioning System. Connect the speed control servo vacuum hose and secure the cable to the throttle body. Install the grille upper support bracket, hood lock support and condenser upper mounting brackets.
20. Install the grille assembly including gravel deflector. Fill the crankcase with specified type and

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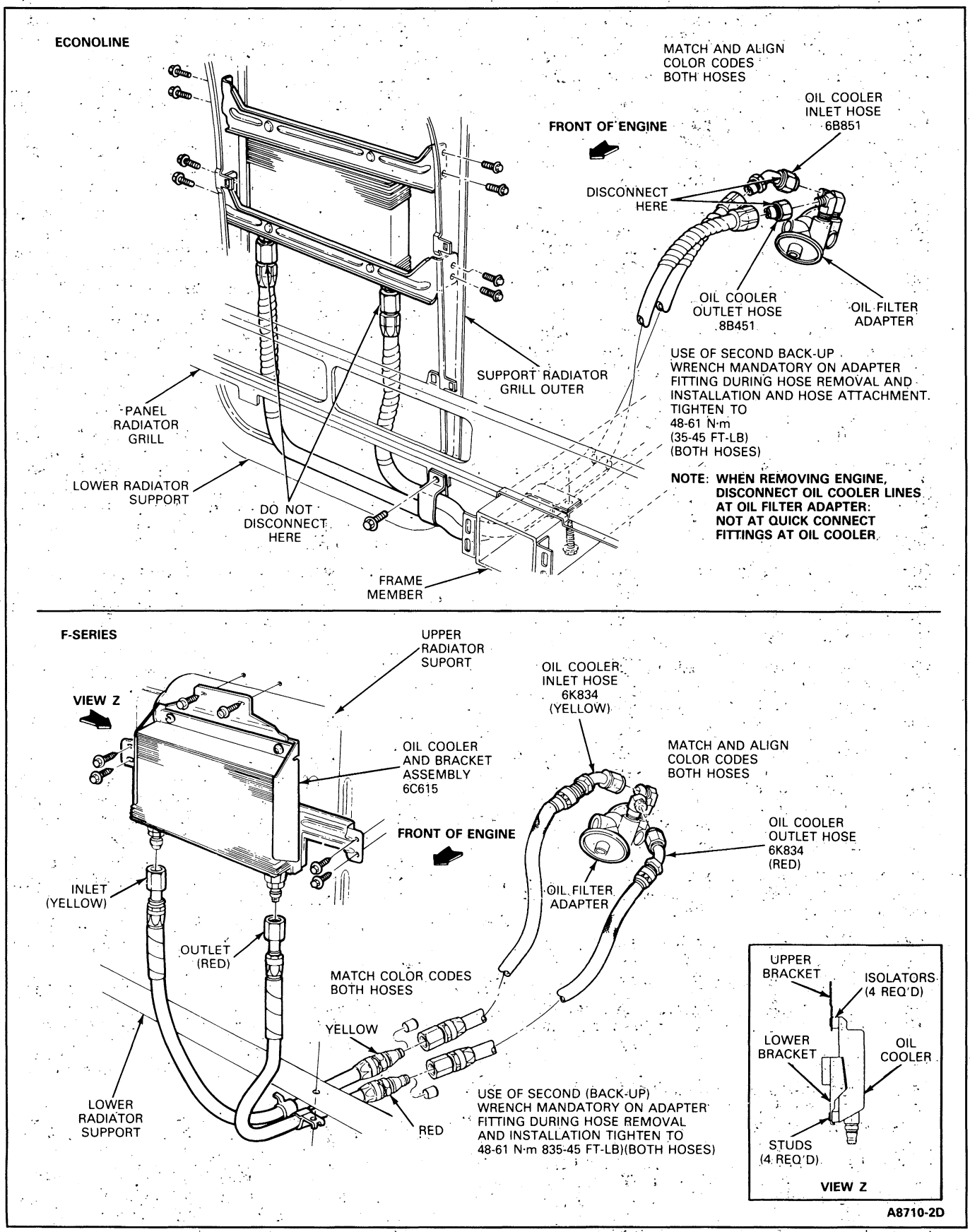


FIG. 7 Engine Oil Cooler Disconnect Points

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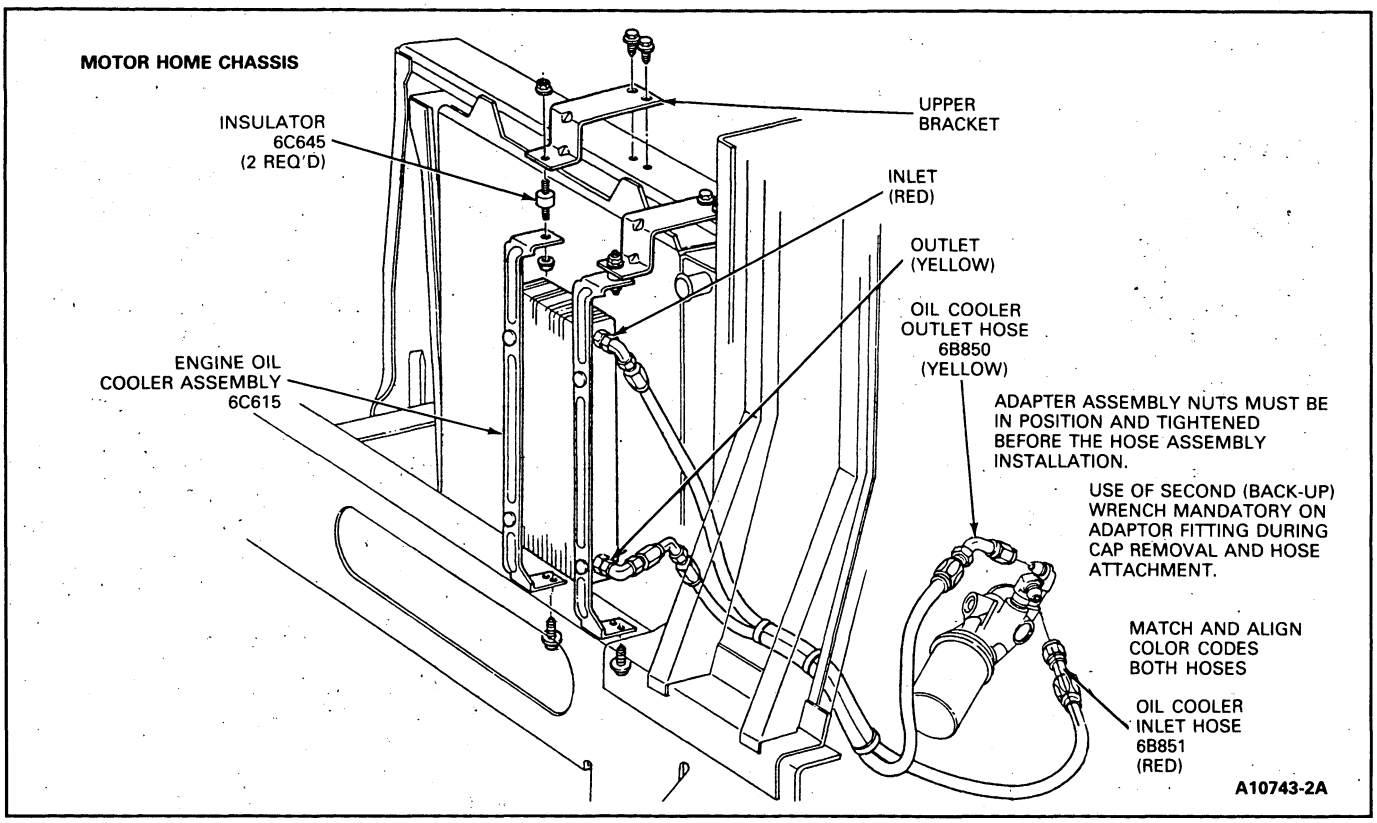


FIG. 7A Engine Oil Cooler Disconnect Points (Continued)

quantity engine oil. Fill and bleed the cooling system. Adjust the tension of drive belt to specifications. Refer to Section 27-02, Cooling System Service and Section 27-06, Accessory Drive Belt Service.

21. Connect battery, start engine and check for leaks. Adjust idle speed to specifications on engine decal.
22. Evacuate and charge the A/C system, if so equipped. Refer to Section 36-30, Air Conditioning, General Service. Install the air cleaner assembly.
23. Install the engine cover.

Electronic Fuel Injection

Refer to Section 24-32 for service of EFI components.

F-250—F-350 — F-Super Duty Chassis Cab and Motor Home Chassis

Removal

1. Drain the cooling system and the crankcase. Refer to Section 27-02, Cooling System Service. Remove hood. Refer to Section 44-21 Hood and Hinges.
2. Disconnect the battery cables from the battery.
3. Disconnect the thermactor air pump inlet hose at the front of the air cleaner housing.
4. Disconnect the air outlet tube assembly at the throttle body and upper intake manifold. The air cleaner assembly and air outlet tubes can now be removed, after disconnecting the air inlet tube at the air cleaner.
5. Remove the thermactor bypass valve hose connected to the air inlet tube and remove the air inlet tube.
6. Remove the air cleaner and intake duct assembly, including the crankcase ventilation hose and carbon canister hose.
7. Disconnect the radiator lower and upper hose at the radiator. If equipped with an automatic transmission, disconnect the transmission oil cooler lines. If equipped with engine oil cooler, disconnect the cooler lines at the oil filter adapter. **CAUTION: Do not attempt to disconnect engine oil cooler lines at quick connect fittings behind or at the cooler on F-Series (Fig. 7), or damage to fittings will occur.**
8. If so equipped, discharge the A/C system and remove the A/C condenser. Refer to Section 36-61, F-150 through F-350, F-Super Duty, and Bronco Manual A/C—Heater System. Disconnect A/C lines at the compressor.
9. Remove the fan shroud and position it over the fan. Remove the radiator. Refer to Section 27-04, Radiators. Remove the fan shroud, fan clutch, belts and pulley (Fig. 8).
10. Remove the alternator bolts and allow the alternator to swing down and out of the way.
11. Disconnect throttle and transmission linkage at throttle body and remove accelerator cable bracket from upper intake manifold. Remove the speed control hardware if so equipped.
12. Disconnect the oil pressure sending unit wire from the sending unit. Disconnect evaporative emission hoses at the evaporative canister.
13. Disconnect the fuel lines at quick disconnect couplings and vacuum lines to the intake manifold.

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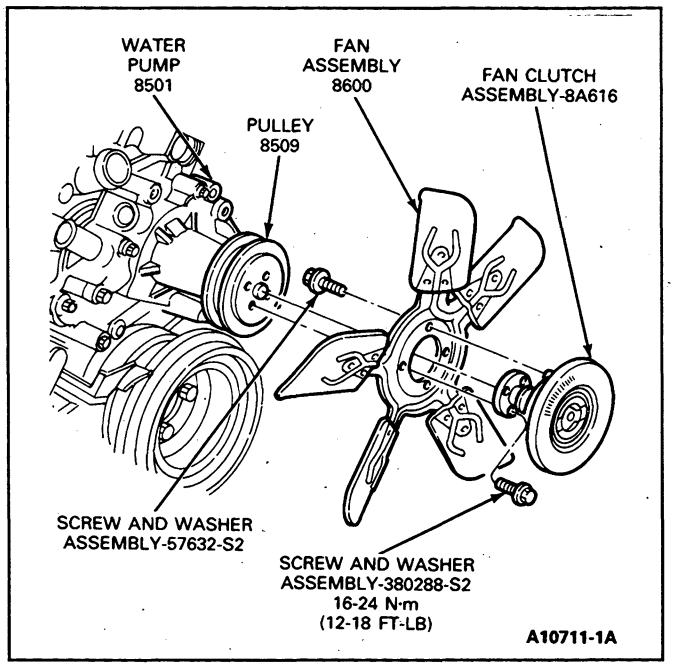


FIG. 8 Fan Blade Assembly E-250—E-350, F-250—F-350 and F-Super Duty

14. Disconnect EGR tube at LH exhaust manifold and upper intake manifold. Plug manifold opening.
15. Disconnect power brake booster vacuum hose, if so equipped.
16. Disconnect the heater hoses from the water pump and intake manifold. Disconnect the coolant temperature sending unit electrical connection from the sending unit.
17. Disconnect exhaust air supply bypass valve hose at MTA check valve.
18. Remove the flywheel housing-to-engine upper bolts.
19. Disconnect the primary wire from the ignition coil. Remove the wire harness from the LH rocker arm cover and position the wires out of the way. Disconnect the ground strap from the cylinder block.
20. Remove oil fill tube, dipstick and tube from engine.
21. Raise the front of the vehicle. Disconnect the starter cable from the starter. Remove the starter. Refer to Section 28-02, Positive Engagement Starter.
22. Disconnect the muffler inlet pipes from the exhaust manifolds. Disconnect the engine support insulators from the brackets on the frame underbody (Figs. 11 and 12).
23. On a vehicle with automatic transmission, remove the converter inspection plate. Remove the torque converter-to-flywheel attaching bolts.

    On vehicles with manual transmission, remove the rear cover plate from the flywheel housing. Remove the remaining flywheel housing-to-engine bolts.
24. If so equipped, disconnect A/C compressor magnetic clutch lead wire. Refer to Section 36-61, F-150—F-350, F-Super Duty and Bronco Manual Air Conditioning—Heater System.
25. Lower the vehicle, and then support the transmission. Install Engine Lifting Brackets T70P-6000 or equivalent onto the intake manifold lifting eyes. Then, attach the engine lifting sling.

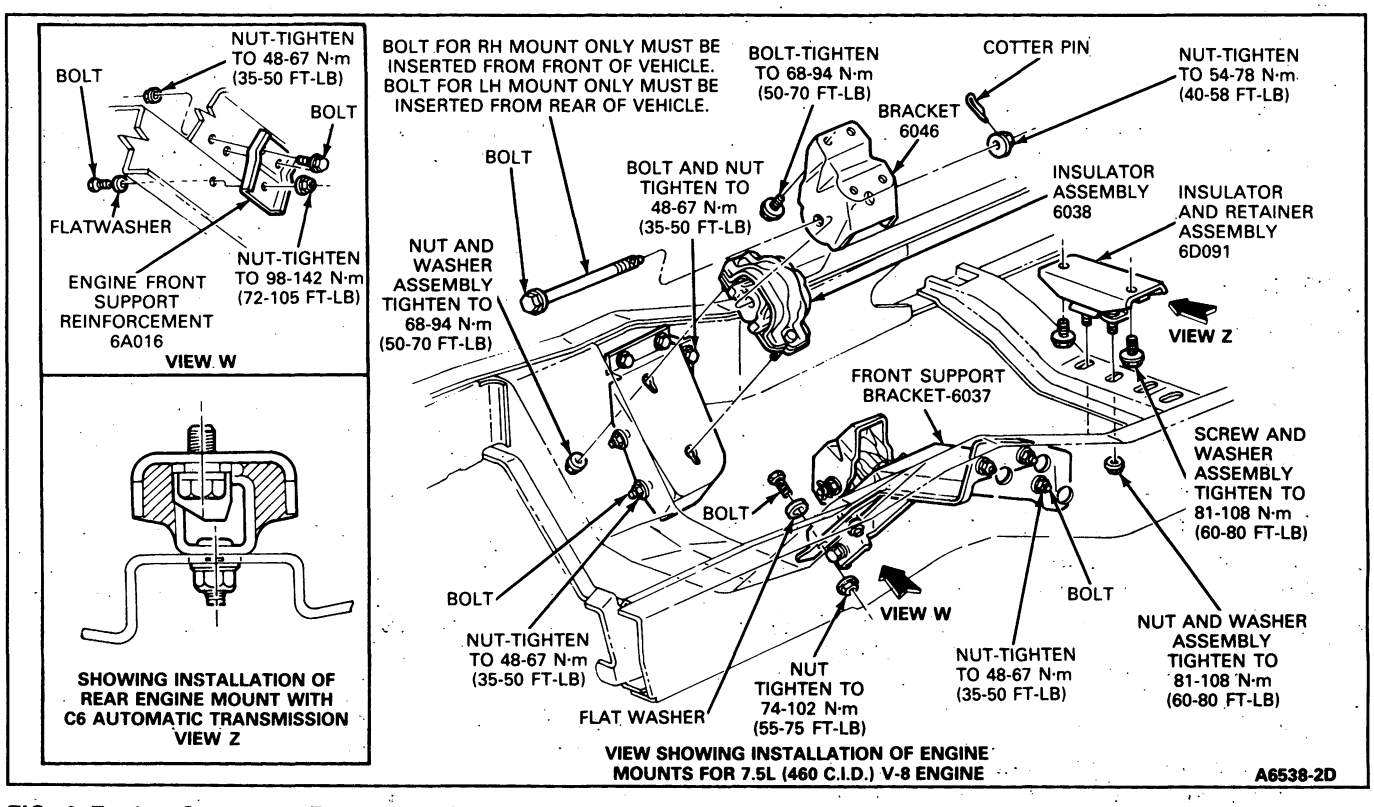


FIG. 9 Engine Supports—E-250—E-350

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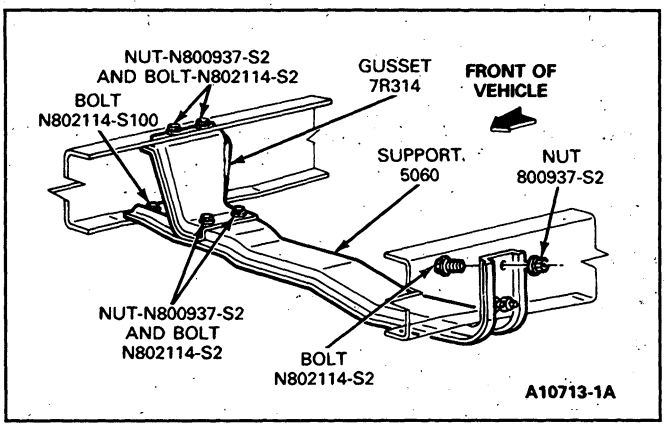


FIG. 10 Engine Rear Support and Insulator—F-350-4x4

26. Raise the engine slightly and carefully pull it from the transmission. Carefully lift the engine out of the engine compartment so that the rear cover plate is not bent or other components damaged. Install the engine on a work stand.

Installation

1. Attach the engine lifting brackets and sling. Remove the engine from the work stand.
2. Lower the engine carefully into the engine compartment. Ensure the dowels in the block are through the rear cover plate, then engage dowels with holes in the flywheel housing.

   On a vehicle with manual transmission, start the transmission main drive shaft into the clutch disc. It may be necessary to adjust the position of the transmission in relation to the engine if the input shaft will not enter the clutch disc. **If the engine hangs up after the shaft enters, turn the crankshaft slowly (transmission in gear) until the shaft splines mesh with the clutch disc splines.**
3. Install the flywheel housing upper bolts.
4. Install the engine support and insulator-to-bracket nuts and washers. Tighten to 81-108 N·m (60-80 ft-lb). Disconnect the engine lifting sling and remove the lifting eyes.
5. Raise the front of the vehicle. Connect both exhaust manifolds to the muffler inlet pipes. Tighten the nuts to specifications. Refer to Section 26-01, General Exhaust System Service.
6. Position and install the starter and the starter cable. Refer to Section 28-02, Positive Engagement Starter.
7. Install the remaining flywheel housing-to-engine bolts.
8. On a vehicle with automatic transmission, install the converter-to-flywheel attaching bolts. Install the converter inspection plate or the rear cover plate on manual transmissions.
9. Remove the support from the transmission and lower the vehicle.
10. If so equipped, connect the A/C compressor magnetic clutch lead wire. Refer to Section 36-61, F-150—F-350, F-Super Duty and Bronco Manual Air Conditioning—Heater System.
11. Connect the wiring harness to the LH rocker arm cover and connect the coil wire.
12. Connect the water temperature sending unit wire.
13. Connect the accelerator cable bracket to the intake manifold. Connect the transmission and throttle linkage to the throttle body, and speed control linkage, if so equipped.
14. Connect the fuel lines and the oil pressure sending unit wire. Reconnect evaporative emission hoses at the evaporative canister.
15. Install the pulley, belt, spacer and fan. Position the fan shroud over the fan.
16. Position the alternator and install the alternator bolts. Connect the battery ground cable. Adjust the belt tension to specification. Refer to Section 27-06, Accessory Drive Belt Service.
17. If so equipped, connect two A/C lines to the A/C compressor. Refer to Section 36-61, F-150—F-350, F-Super Duty and Bronco Manual Air Conditioning—Heater System.
18. Install the radiator. Refer to Section 27-04 Radiators. Connect the radiator upper and lower hoses. Connect the transmission oil cooler lines, if so equipped, and engine oil cooler lines. Tighten, using a backup wrench. Install the fan shroud.
19. If so equipped, install the A/C condenser to the radiator. Refer to Section 36-61, F-150—F-350, F-Super Duty and Bronco Manual Air Conditioning—Heater System Section.
20. Connect the heater hose at the water pump. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service. Fill the crankcase with the proper grade and quantity of oil. Connect the power brake booster vacuum hose, if so equipped.
21. Operate the engine at fast idle and check all gaskets and hose connections for leaks.
22. Install the air cleaner and intake duct assembly including the crankcase ventilation hose and carbon canister hose.
23. Evacuate and charge the A/C system, if so equipped. Refer to Section 36-30, Air Conditioning, General Service.
24. Install hood. Refer to Section 44-21, Hood and Hinges.

Engine Front Supports

Front supports are located on each side of the cylinder block. The following procedures apply to either support:

E-250—E-350

Removal

1. Support the engine with a jack and a wood block placed under the oil pan.
2. Remove the locknuts from the bolts attaching the support bracket (Fig. 9) to the frame crossmember and frame side rail.
3. Remove the through bolt attaching the engine support bracket to the insulator.
4. Raise the engine with the jack, until the insulator is clear of the cup-shaped engine bracket.
5. Remove the insulator and frame bracket (Fig. 9) as an assembly.
6. Remove the nuts attaching the insulator to the frame bracket.

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Installation

1. Assemble the insulator to the frame bracket and install the attaching nuts. **The insulator should be installed so that the word TOP is visible on either side of the engine (Fig. 9).** Tighten the attaching nuts to 68-94 N·m (50-70 ft-lb).
2. Position the insulator and frame bracket assembly to the engine insulator bracket and the frame crossmember. Install the through bolt attaching the insulator to the engine bracket. The through bolt for the RH insulator must be installed from the front of the engine. The through bolt for the LH insulator must be installed from the rear of the engine. Tighten the nut to 55-78 N·m (40-58 ft-lb) and install the cotter pin. Lower the engine.
3. Install the locknuts on the bolts attaching the frame bracket to the crossmember. Tighten the frame bracket attaching bolt locknuts to 48-67 N·m (35-50 ft-lb). **Tighten the crossmember bolts and locknuts on the LH support bracket to 98-142 N·m (72-105 ft-lb).** Remove the jack and wood block.

Engine Rear Support

Removal

1. Remove the attaching bolts, nut and washer (Figs. 10, 11, 12 and 13).
2. Raise the transmission slightly to provide clearance; then, remove the insulator and insulator retainer.

Installation

1. Position the insulator and retainer (Figs. 10, 11, 12 and 13). Install the insulator-to-extension housing bolts and lockwashers. Tighten to 68-94 N·m (50-70 ft-lb) on E-250—E-350; 60-80 N·m (44-59 ft-lb) on F-250—F-350 and F-Super Duty.
2. Lower the transmission and install the insulator-to-frame crossmember nuts. Tighten the nuts to 68-94 N·m (50-70 ft-lb) on E and F-Series (Figs. 10, 11, 12 and 13).

Engine Components

Figs. 14 and 15 are typical and are references for procedures outlined. The parts descriptions and basic numbers in the illustration keys correspond with the Ford Master Parts Catalog.

Crankcase Ventilation System

F-250—F-350 — F-Super Duty

Removal

1. Remove ventilation intake hose from the air cleaner and the oil fill tube on LH rocker cover.
2. Disconnect and remove ventilation filter pack from dirty side of air cleaner assembly.
3. Remove the PCV valve from the grommet on the RH rocker cover (Fig. 16).
4. Disconnect the crankcase ventilation hose at the upper intake manifold and at the evaporative emission harness.

Installation

1. Install the PCV valve and hose into the grommet on the RH rocker cover.
2. Install the ventilation hose at the emission harness and at the upper intake manifold.
3. Install a new filter pack in air cleaner assembly.
4. Install the ventilation intake hose to the oil fill tube and the air cleaner.
5. Start the engine and check for leaks.

E-250—E-350

Removal

1. Disconnect the crankcase vent front hose from the air cleaner.
2. Remove ventilation intake hose from the air cleaner and the oil fill tube on the LH rocker cover.

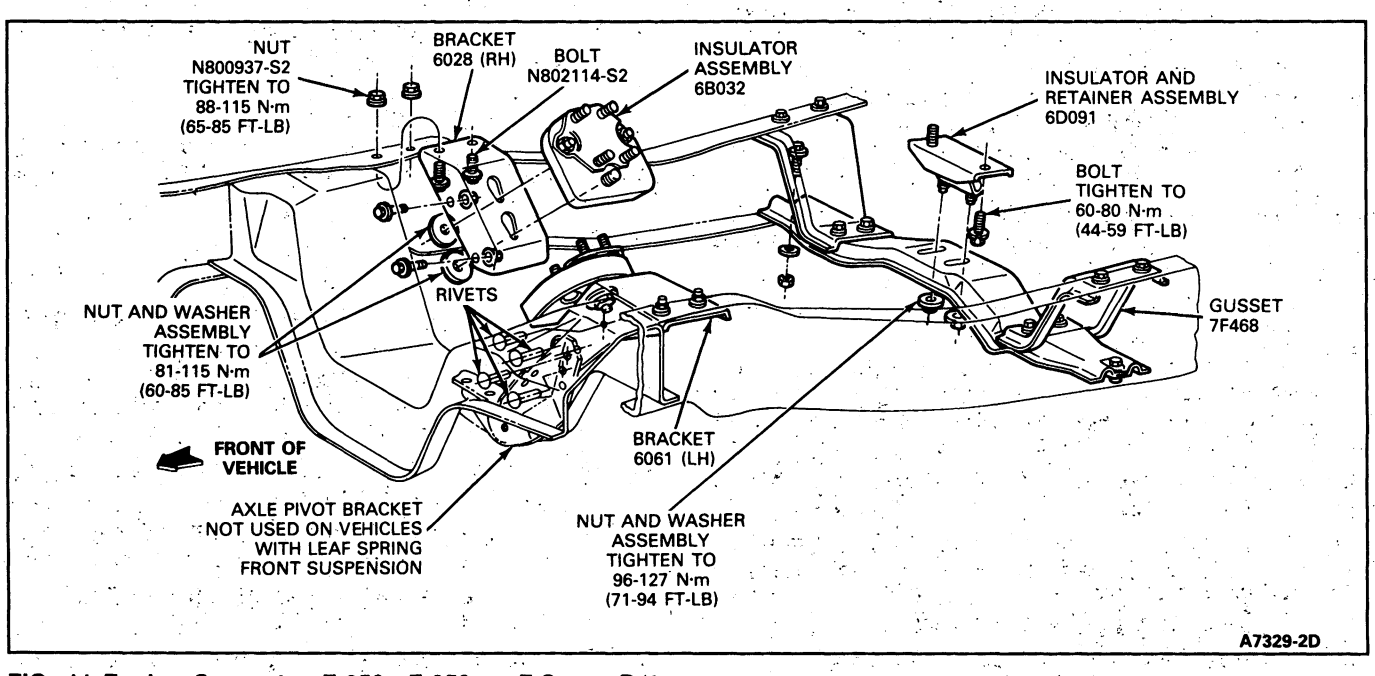


FIG. 11 Engine Supports—F-250—F-350 — F-Super Duty

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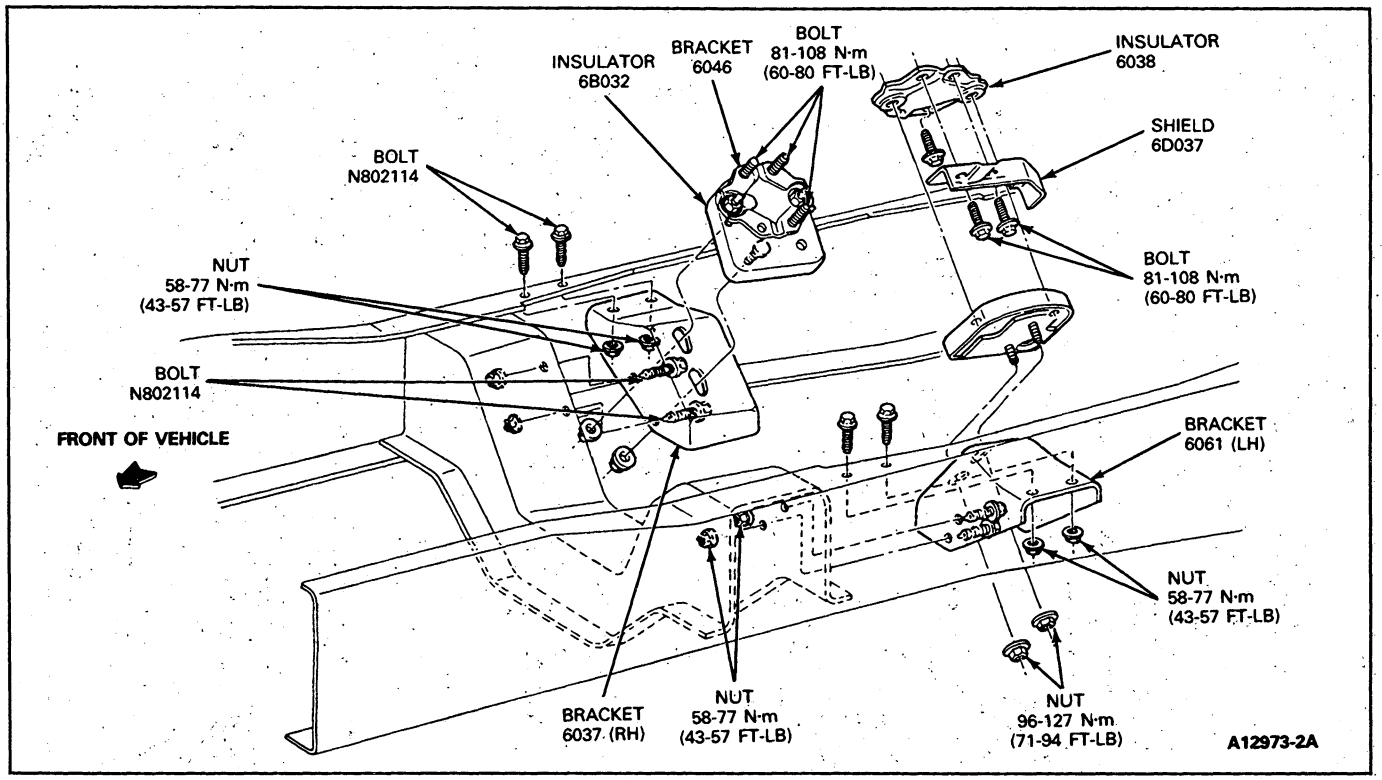


FIG. 12 Engine Support—F-Super Duty Motor Home Chassis

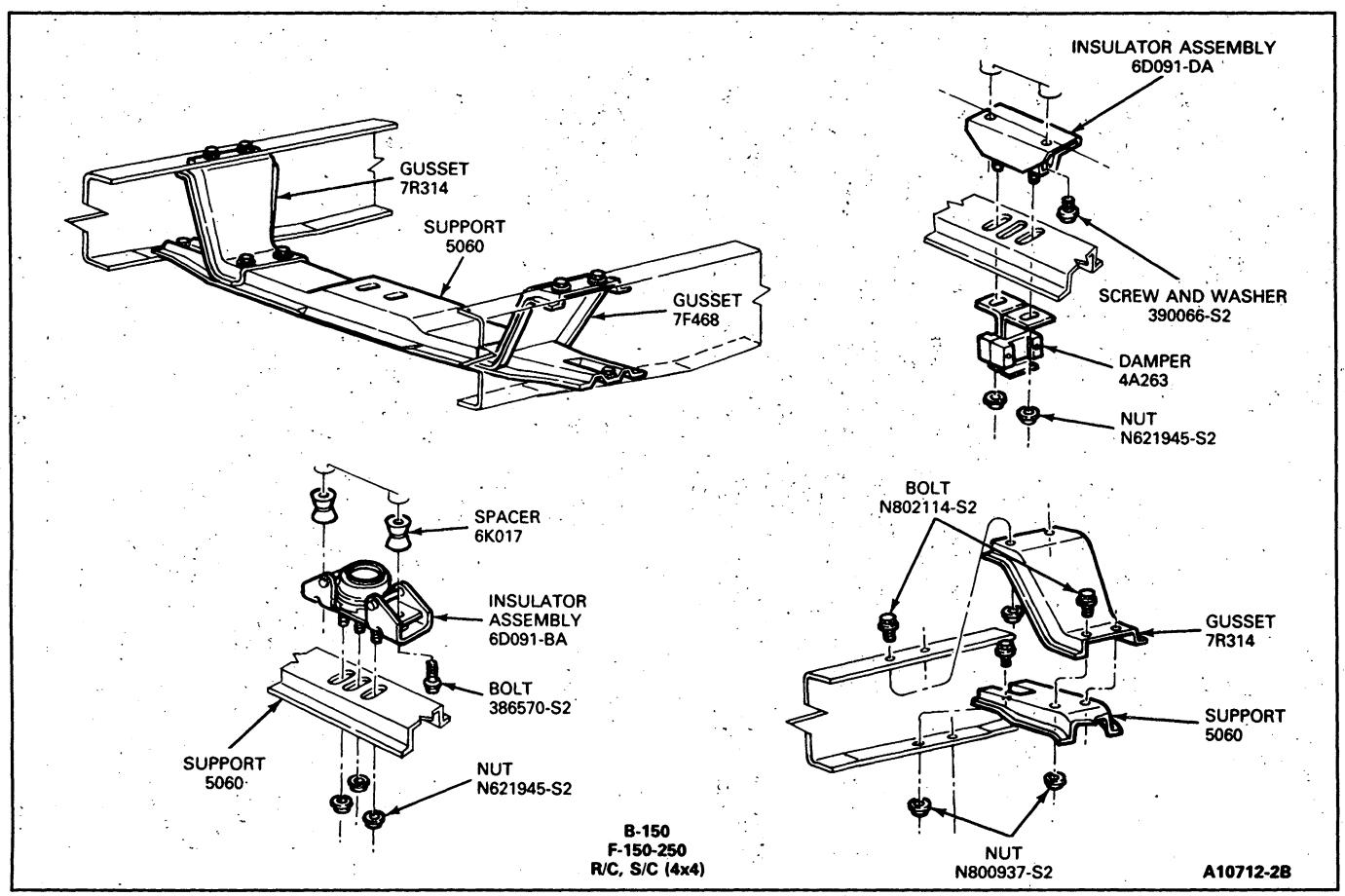


FIG. 13 Rear Engine Support and Insulator—F150—F-250-4x4

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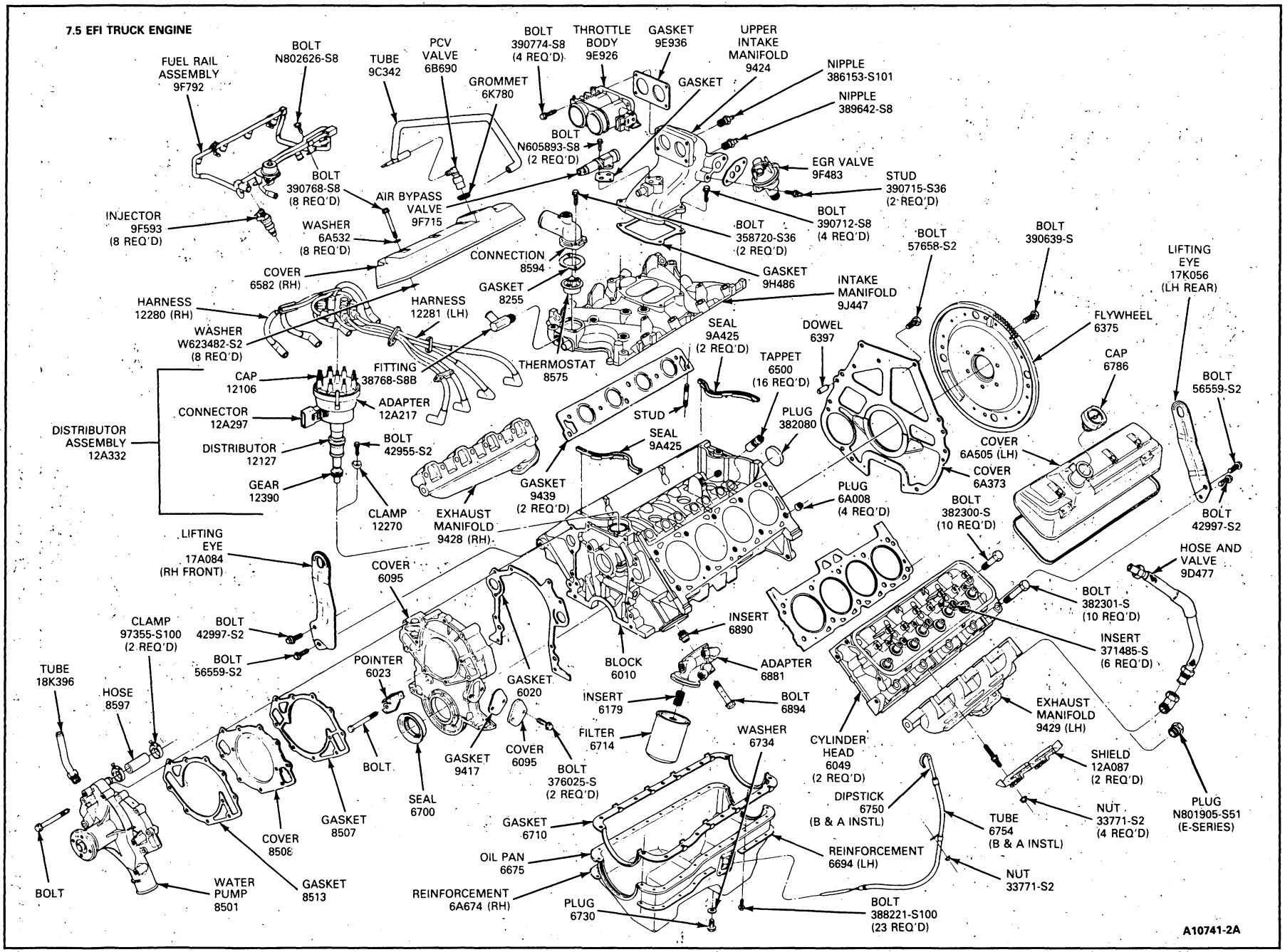


FIG. 14 External Exploded View—7.5L EFI (460 CID) V-8 Engine

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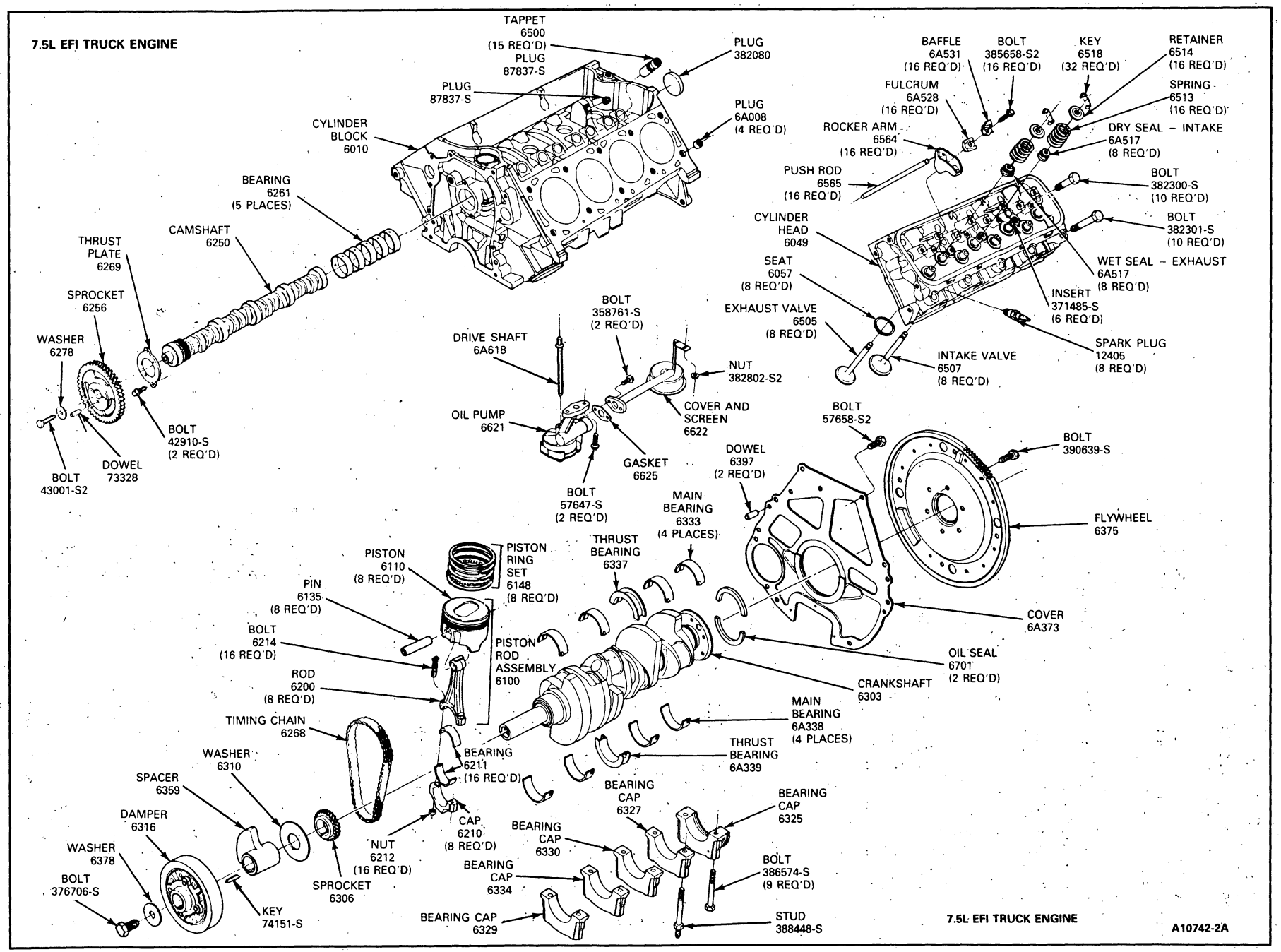


FIG. 15 Internal Exploded View—7.5L EFI (460 CID) V-8 Engine

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3. Disconnect and remove ventilation filter pack from dirty side of air cleaner assembly.
4. Remove the PCV valve from the grommet on the RH rocker cover (Fig. 16).
5. Disconnect the crankcase ventilation hose at the upper intake manifold and at the evaporative emission harness.

Installation

1. Insert the PCV valve and hose into the grommet in the RH rocker arm cover.
2. Install the ventilation hose at the emission harness and at the upper intake manifold.
3. Install a new filter pack in the air cleaner assembly.
4. Install the ventilation intake to the oil fill tube and the air cleaner.
5. Start the engine and check for leaks.

Valve Rocker Arm Cover and Rocker Arm

The valve rocker arm is shown in Fig. 16.

F-Series and E-Series

Removal

1. Disconnect battery(s).
2. Remove air cleaner and intake duct assembly.
3. Remove thermactor exhaust air supply control valve and bracket assembly, and ignition coil mounting bracket.
4. Disconnect MTA hose at thermactor valve.
5. Disconnect thermactor air control valve to air pump hose and tube inlet assembly.
6. Disconnect spark plug wires from spark plugs using Spark Plug Wire Remover T74P-6666-A or equivalent and position wires out of the way.
7. Remove crankcase ventilation PCV valve from the valve rocker arm cover (for RH cover).
8. Position wiring and vacuum harnesses to gain access in order to remove RH valve rocker arm cover.
9. Remove the valve rocker arm cover(s).
10. Remove fulcrum bolt, oil deflector, fulcrum seat and rocker arm.

Installation

1. Apply Ford Multi-Purpose Grease D0AZ-19584-AA or equivalent to the top of the valve stems, the rocker arm and fulcrum seats.
2. Position the No. 1 piston at TDC at the end of the compression stroke (POSITION 1 in Fig. 6). Install the rocker arm, fulcrum seat, oil deflecton and fulcrum bolt on the following valves:

   No. 1 Intake No. 1 Exhaust

   No. 3 Intake No. 8 Exhaust

   No. 7 Intake No. 5 Exhaust

   No. 8 Intake No. 4 Exhaust

2. Position the crankshaft in POSITION 1 in Fig. 6 and install the rocker arm, fulcrum seat, oil deflecton and a bolt on the following valves:

   No. 2 Intake No. 2 Exhaust

   No. 4 Intake No. 3 Exhaust

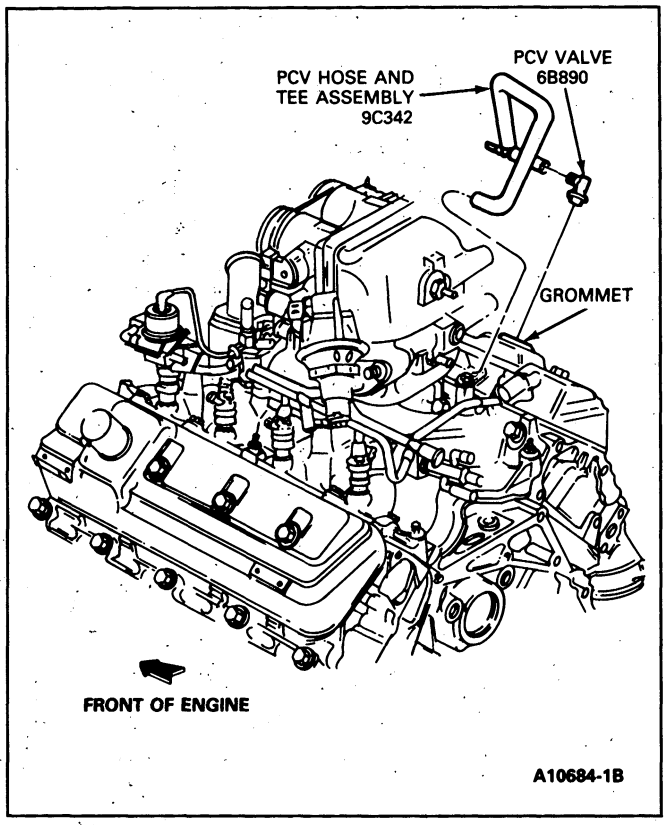


FIG. 16 Crankcase Emission Tubing

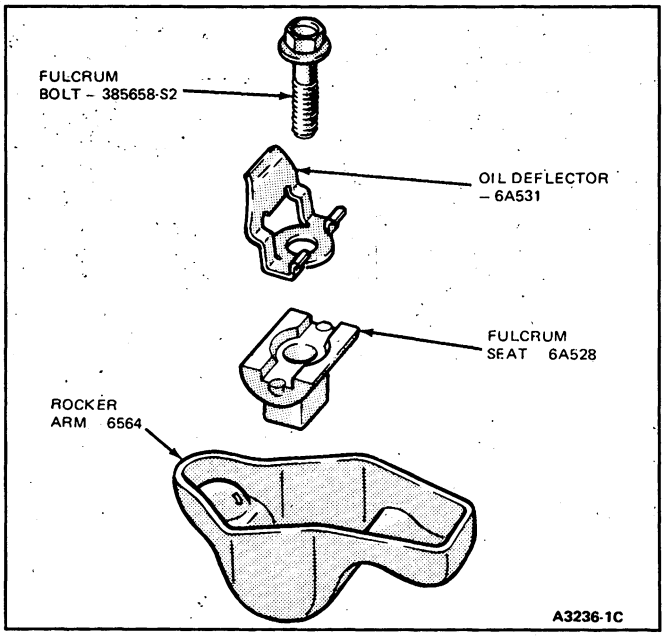


FIG. 17 Rocker Arm and Related Parts

   No. 5 Intake No. 6 Exhaust

   No. 6 Intake No. 7 Exhaust

Ensure the fulcrum seat base is inserted into its slot on the cylinder head before tightening the fulcrum bolts. Tighten the fulcrum bolt to 25-33 N·m (18-25 ft-lbs). Adjust the valve clearance as outlined under Adjustments.

3. Clean valve rocker arm cover(s) and cylinder head sealing surface(s). Position seal in cover seal

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groove, making sure that the seal tang is aligned with notch in the cover.

4. Position cover(s) on the cylinder head(s). Tighten the four rocker arm cover bolt and washer assemblies to 8-12 N·m (6-9 ft-lb) from right-to-left (Fig. 16).
5. Install PCV valve (RH cover).
6. Install ignition coil mounting bracket and connect distributor to spark plug wire assembly.
7. Connect thermactor air control valve and bracket assembly.
8. Install thermactor air supply tube and MTA hose at thermactor valve.
9. Install air cleaner and intake duct assembly.
10. Connect battery(s).
11. Start engine and check for leaks.

Valve Rocker Arm (Cam Follower) and Hydraulic Lash Adjuster

Removal

1. Remove the valve rocker arm cover and associated parts as required.
2. Rotate the camshaft so that the base circle of the cam is facing the applicable cam follower.
3. Using Valve Spring Compressor Tool T70P-6049-A or equivalent (Fig. 18), collapse the valve spring and slide the cam follower over the lash adjuster and out.
4. Lift out the hydraulic lash adjuster.

Installation

1. Rotate the camshaft so that the base circle of the cam is facing the applicable cam follower.

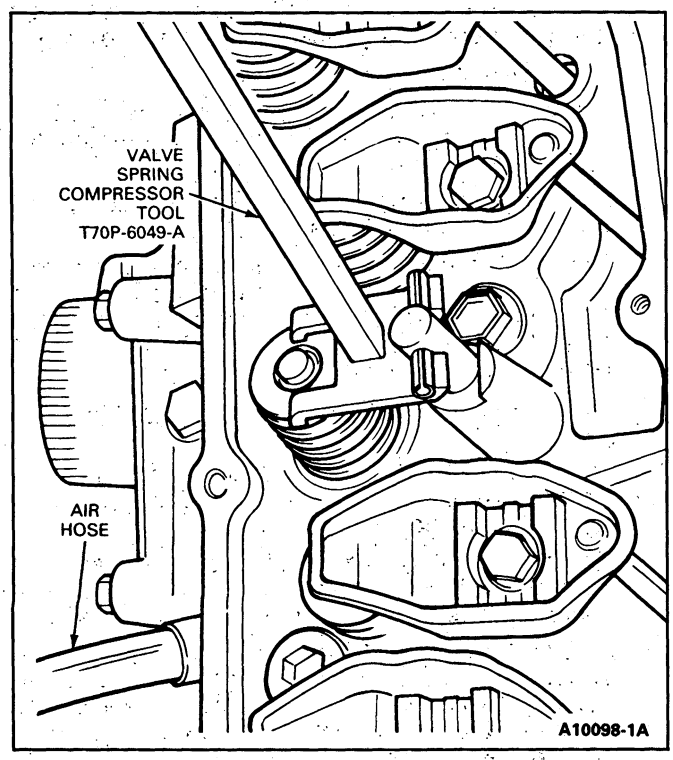


FIG. 18 Compressing Valve Spring—In Chassis

2. Place the hydraulic lash adjuster in position in the bore.
3. Collapse the valve spring using Valve Spring Compressor Tool T70P-6049-A or equivalent (Fig. 18). Position the cam follower over the lash adjuster and the valve stem.
4. Clean the sealing surfaces of the valve cover and cylinder head.
5. Position seal in cover seal groove, making sure that the seal tang is aligned with notch in the cover.
6. Position cover(s) on the cylinder head(s). Tighten the rocker arm cover bolt and washer assemblies to 8-12 N·m (6-9 ft-lb) from right-to-left (Fig. 16).
7. Install the air cleaner and all other hardware removed.
8. Run the engine at fast idle and check for oil leaks.

Valve Spring, Retainer and Stem Seal

If the valve or valve seat has not been damaged, the valve spring damper assembly, seals and retainers may be replaced by holding the affected valve against its seat using compressed air. Use an appropriate air line tool installed in the spark plug hole. A minimum of 965 kPa (140 psi) line pressure is required. If air pressure does not hold the valve shut, the valve is damaged or burned and the cylinder head must be removed and serviced. Refer to Section 21-01, General Gasoline Engine Service.

Removal

1. Remove the valve rocker arm cover and associated parts as required.
2. Remove the cam follower.
3. Using Valve Spring Compressor Lever T70P-6049-A or equivalent (Fig. 18), compress the valve spring and remove the retainer locks, spring retainer, and valve damper assembly spring. Remove and discard the stem seal.
4. If air pressure has forced the piston to the bottom of the cylinder, any removal of air pressure will allow the valve(s) to fall into the cylinder. A rubber band, tape or string wrapped around the end of the valve stem will prevent this condition and will still allow enough travel to check the valve for binds.
5. Inspect the valve stem for damage. Rotate the valve and check the stem tip for eccentric movement. Move the valve up and down through normal travel in the valve guide and check the stem for binds. If the valve has been damaged, it will be necessary to remove the cylinder head and service. Refer to Section 21-01, General Gasoline Engine Service.

Installation

NOTE: Unique exhaust and intake guide mounted valve stem seals are required and care should be used to install the correct seal in the appropriate location. The seals are identified on one end with IN for intake and EX for exhaust.

1. Install a new valve stem seal using a plastic installation cap using Valve Seal Installer T73P-6571-A or equivalent (Fig. 19) and the procedure given in Figure 20. Install the valve spring damper assembly retainer and locks. Turn off the air and remove the air line and adapter.

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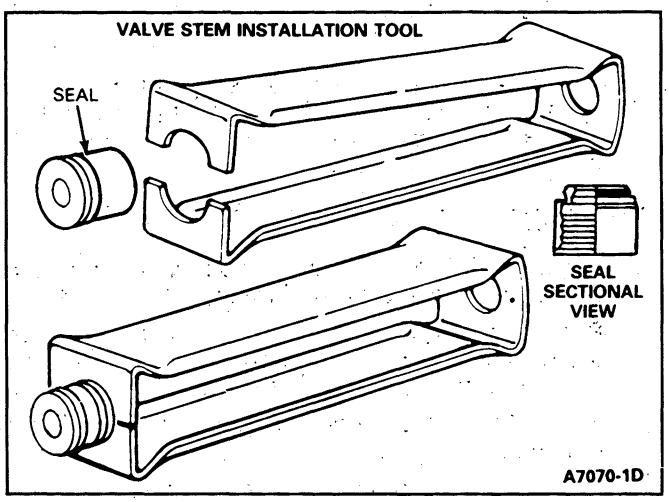


FIG. 19 Valve Stem Seal Installation Tool

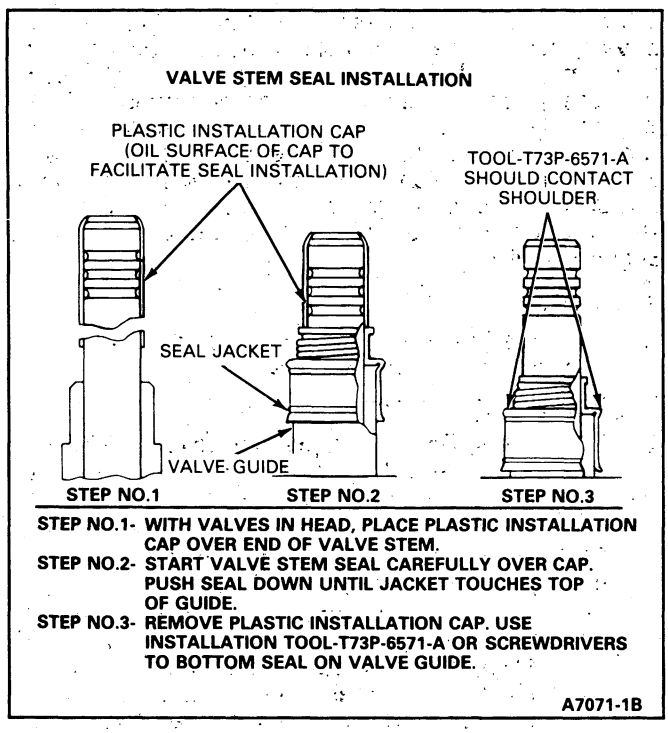


FIG. 20 Valve Stem Seal Installation

2. Apply Ford Multi-Purpose Grease D0AZ-19584-AA or equivalent to all contact surfaces of the cam follower. Install cam follower and the spark plug.
3. Install the rocker arm cover as outlined.

Intake Manifold

Removal

1. Disconnect battery(s).
2. Drain cooling system. Remove air cleaner and intake duct assembly.
3. Remove ignition coil mounting bracket from LH and RH sides of engine and remove high tension lead at the coil.
4. Disconnect and remove external EGR tube and both thermactor exhaust air supply manifold tubes.
5. Disconnect upper radiator hose at engine.

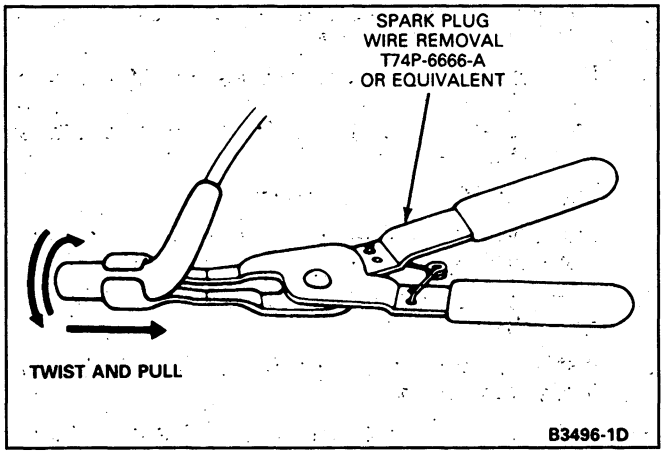


FIG. 21 Removing Wires From Spark Plugs

6. Disconnect heater hoses at intake manifold and water pump. Loosen water bypass hose at intake manifold.
7. Disconnect PCV valve and hose (RH cover). Disconnect all the vacuum lines at rear of intake manifold and tag them for reference during installation.
8. Disconnect wires at the spark plugs using Spark Plug Wire Remover T74P-6666-A or equivalent (Fig. 21) and move out of the way. Disconnect and remove the distributor cap and wires as an assembly.
9. Remove distributor. Refer to Section 23-01, General Ignition Service for breakerless ignition systems.
10. Disconnect accelerator linkage and transmission kickdown linkage at the throttle body. Remove speed control linkage bracket, if so equipped, from the intake manifold and disconnect it from the throttle body. Remove bolts holding accelerator linkage cable, and position linkage out of way.
11. Disconnect fuel lines at fuel rail.
12. Disconnect wiring harness from main wiring harness. Wiring harness and lower intake manifold to be removed as an assembly.
13. Remove throttle body heater hose at water pump and intake manifold heater outlet connection.
14. Remove attaching bolts. Remove intake manifold and throttle body as an assembly using engine lifting eyes. **If necessary to pry manifold away from the cylinder heads, do not damage the gasket sealing surfaces.**
15. Remove and discard intake manifold gaskets and seals.
16. If manifold is to be further disassembled refer to Section 24-32, Electronic Fuel Injection—7.5L (460 CID) V-8 Engine.
17. Remove all gasket material from the machined surfaces of the manifold. Clean the manifold in a suitable solvent and dry it with compressed air.
18. Inspect the manifold for cracks, damaged gasket surfaces, or other wear or damage that would make it unfit for further service. Replace all fasteners that are stripped or otherwise damaged. Remove all filings and foreign matter that may have entered the manifold as a result of repairs.

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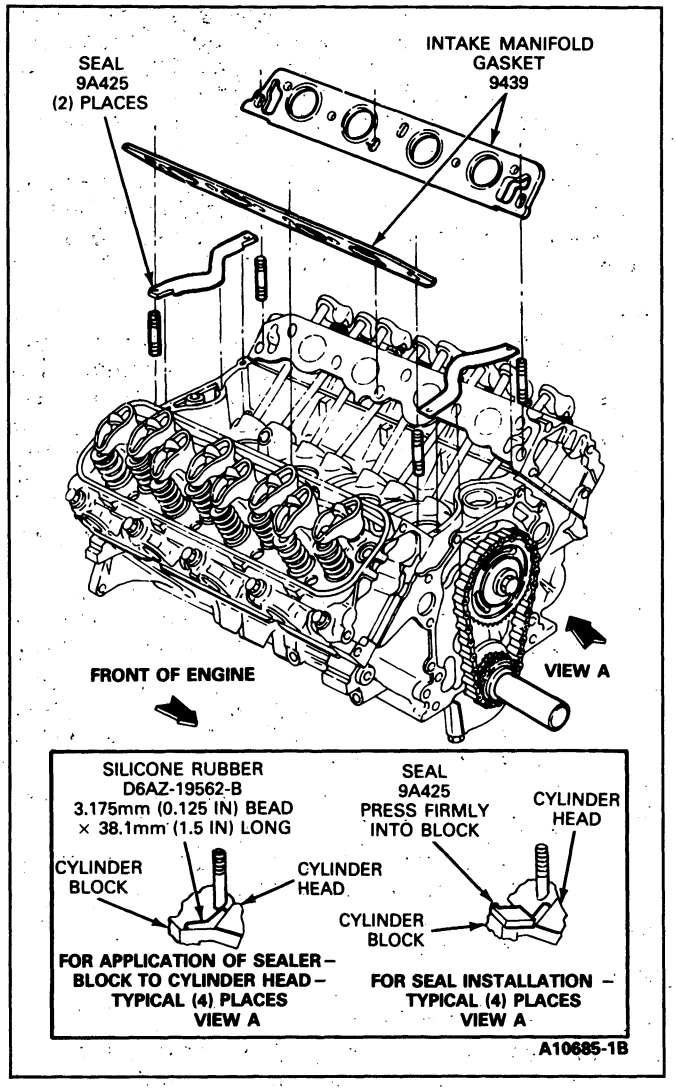


FIG. 22 Lower Intake Manifold Installation

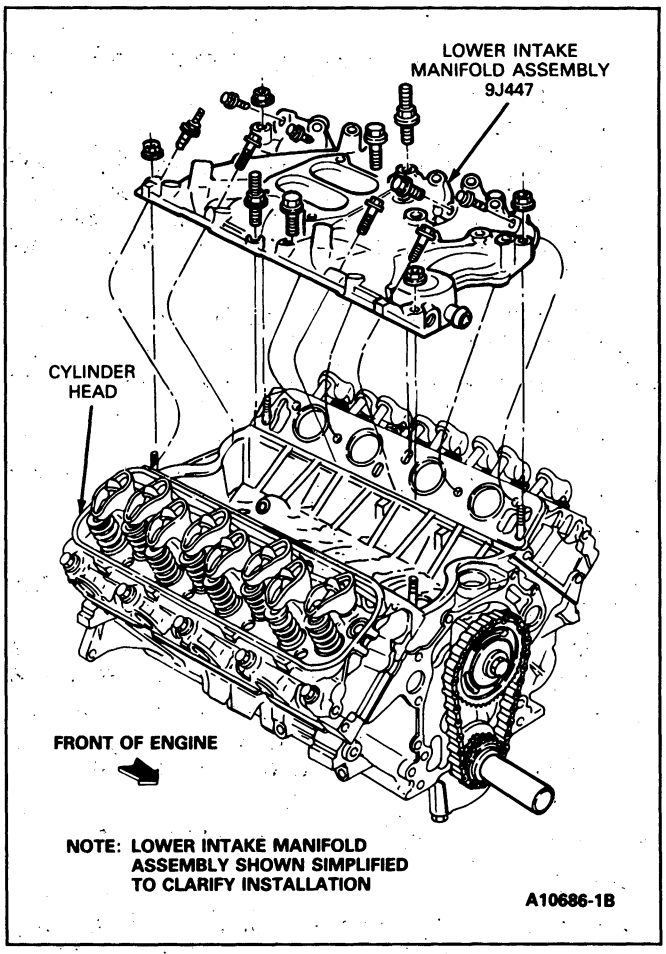


FIG. 23 Intake Manifold Torque Sequence

Installation

1. Clean mating surfaces of intake manifold, cylinder heads, and cylinder block. Use a solvent such as Ford Spot Remover B7A-19521-A or equivalent degreasing agent.
2. Apply a 3.2mm (1/8-inch) diameter bead of sealer, in and along the joint, the full width of the cylinder block seal mounting surface (four corners) as shown in Fig. 21.
3. Install the intake manifold gasket and the front and rear intake manifold to cylinder block seals (Fig. 22). Apply a 1.6mm (1/16-inch) bead of sealer at the outer end of each intake manifold seal for the full width of the seal.

   NOTE: This sealer sets up within 15 minutes after application. Assemble promptly.
4. Carefully lower intake manifold into position over four studs in ends of cylinder heads. **When intake manifold is in place, run finger around seal area to ensure seals are in place. If seals have shifted, remove manifold and re-position seals.**
5. Ensure intake manifold gaskets are properly aligned. Then, install attaching bolts and stud bolts into holes 1 through 10 (Fig. 23).
6. Install bolts into holes 11 and 12.
7. The lower intake manifold fasteners are secured following a three step rundown procedure as outlined in steps 8 through 10).
8. Install nuts onto studs 13 through 16. Tighten bolts 1 through 12 in sequence to 11-16 N·m (8-12 ft-lb). Tighten nuts 13 through 16 in sequence to 11-16 N·m (8-12 ft-lb).
9. Tighten bolts and nuts 1 through 16 in sequence to 16-30 N·m (12-22 ft-lb).
10. Tighten manifold bolts and nuts 1 through 16 in sequence to 30-47 N·m (22-35 ft-lb).
11. Install external EGR tube and thermactor exhaust air supply tubes.
12. Install water pump bypass hose to intake manifold fitting and heater hot water tube.
13. Connect radiator upper hose to coolant outlet housing.
14. Rotate crankshaft damper until No. 1 piston is at TDC at end of compression stroke. Install the distributor. Refer to Section 23-01, General Ignition Service for breakerless ignition systems.
15. Connect heater hoses at intake manifold and water pump.
16. Install accessory drive belts and tighten to specification.
17. Connect PCV valve and hose to RH valve rocker arm cover.

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18. Connect fuel lines to fuel rail.
19. Install ignition coil mounting brackets on LH and RH sides of engine.
20. Complete all electrical connections.
21. Position accelerator linkage on manifold. Attach accelerator linkage cable. Attach speed control linkage bracket to intake manifold, if so equipped. Install accelerator and kickdown linkage to throttle body.
22. Connect the vacuum lines to their respective ports at rear of intake manifold.
23. Secure distributor cap to distributor. Connect spark plug wires to spark plugs. Connect coil high tension lead to coil.
24. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service.
25. Connect the battery(s).
26. Start engine. Check and adjust ignition timing, if necessary. Connect distributor vacuum lines.
27. Operate engine at fast idle and check for coolant leaks. Check coolant level and refill as necessary.
28. Start the engine and allow it to reach normal operating temperature. Then, while hot, tighten the manifold attaching nuts and bolts to 30-47 N·m (22-35 ft-lb).
29. Install air cleaner and intake duct assembly.

Valve Tappet

The following procedure is applicable for removing one or all of the valve tappets. Before replacing a hydraulic valve tappet for noisy operation, ensure the noise is not caused by improper valve clearance or by worn rocker arms and/or push rods.

Removal

1. Remove intake manifold as outlined.
2. Remove the valve rocker arm covers. Loosen the rocker arm fulcrum bolts and turn rocker arms to one side (Fig. 24).
3. Remove the push rods in sequence.

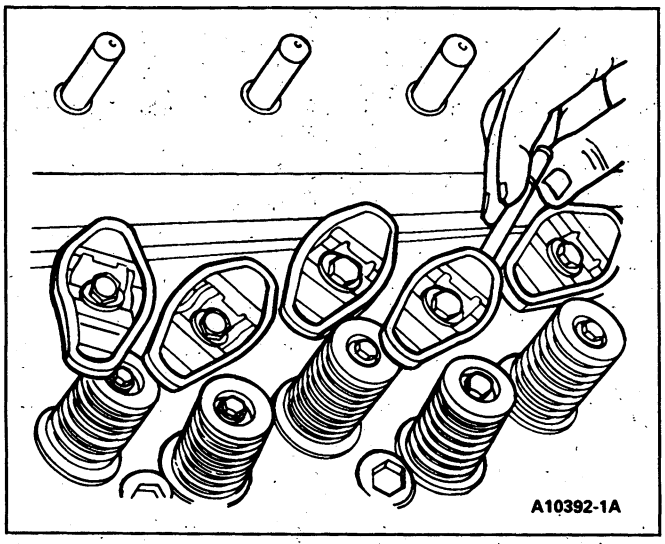


FIG. 24 Removing Valve Push Rod

4. Remove the valve tappets with a magnet. Place them in a rack in sequence. If the tappets are stuck in bores, use Hydraulic Lifter Puller T70L-6500-A or equivalent to remove them. Rotate tappets back and forth to loosen them from gum or varnish deposits.

Refer to Section 21-01, General Gasoline Engine Service for cleaning, inspection and testing procedure. If necessary to disassemble tappet(s), refer to Valve Tappet Disassembly and Assembly.

Installation

1. Clean the outside of valve tappets. Tappets and bores are to be lubricated with recommended engine oil before installation. Install the tappets into their original bores. Check any new tappet for free fit in bore to which it is to be installed. Prior to installation of a new lifter, ensure lifter is full of oil by working the valve tappet plunger up and down until the tappet fills with fluid and all traces of air bubbles has disappeared.
2. Install push rods in original positions. Apply Ford Multi-Purpose Grease D0AZ-19584-AA or equivalent to valve stem tips and push rod ends.
3. Position the rocker arms over the push rods. Tighten the bolts following the procedure under Valve Rocker Arm Installation. Adjust valve clearance as outlined.
4. Install rocker arm covers following procedure under Rocker Arm and Cover Installation.
5. Install intake manifold and throttle body following the instructions under Intake Manifold.

Cylinder Heads

Removal

1. Drain cooling system.
2. Remove intake manifold and carburetor as an assembly following procedure under Intake Manifold Removal.
3. Disconnect muffler inlet pipe at exhaust manifold.
4. Loosen air conditioning compressor drive belt, if so equipped.
5. Remove Thermactor air pump and alternator.
6. Remove the Thermactor air pump bracket bolts and position the mounting bracket to the side (RH head).
7. If equipped with air conditioning, shut off compressor at service valves and remove valves and hoses from compressor. Remove nuts attaching compressor support bracket to water pump. Remove bolts attaching compressor to

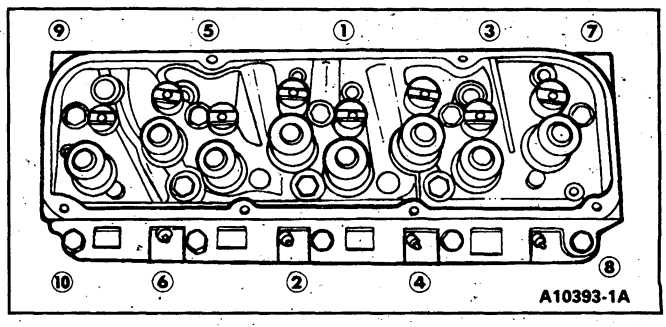


FIG. 25 Cylinder Head Bolt Torque Sequence

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upper mounting bracket and position compressor out of the way. Remove compressor and power steering pump mounting bracket from cylinder head and water pump. Refer to Section 36-65, E-150—E-350 Air Conditioning System.

If not equipped with air conditioning, remove bolts attaching power steering pump bracket to LH cylinder head. Position pump and bracket out of the way.

8. Disconnect the oil filler tube (E-Series and Motor Home Chassis).
9. Remove the Thermactor supply manifold from the exhaust manifold.
10. Remove valve rocker arm covers. Remove rocker arm fulcrum bolts, rocker arms, oil deflectors, fulcrums and push rods in sequence so they can be installed in their original positions.
11. Remove cylinder head attaching bolts. Lift cylinder heads and exhaust manifolds as assemblies from cylinder block with a hoist. **If necessary to loosen cylinder head gasket seal, pry at forward corners of cylinder heads against casting bosses provided on cylinder block. Do not damage machined surfaces of head or block. Discard cylinder head gasket.**
12. If disassembly or machining of cylinder head is required, remove exhaust manifold.

Installation

1. Clean cylinder head, intake manifold, valve rocker arm cover, and cylinder block sealing surfaces. If cylinder head was removed for cylinder head gasket replacement, check flatness of cylinder head and block gasket surfaces. If exhaust manifold was removed, coat cylinder head and manifold port areas with film of graphite grease and install manifold to cylinder head.
2. Place two long cylinder head attaching bolts in two rear lower bolt holes of LH cylinder head. Place a long cylinder head attaching bolt in rear lower bolt hole of RH cylinder head. Use rubber bands to retain bolts in position, above head-to-block mating surface, until cylinder heads are installed.
3. Position new cylinder head gaskets on block over dowels. Do not apply sealer to head gasket surfaces. Place cylinder heads on block, guiding exhaust manifold studs into muffler inlet pipe connections. Install remaining attaching bolts (longer bolts in lower row of bolt holes). Tighten all cylinder head attaching bolts in sequence (Fig. 24) in three steps: first to 108-122 N·m (80-90 ft-lb), then to 136-149 N·m (100-110 ft-lb), and finally to 177-189 N·m (130-140 ft-lb). **When this procedure is used, it is not necessary to tighten bolts after extended operation.**
4. Clean and inspect push rods, one at a time. Clean the oil passage in the push rods with a suitable solvent, and blow out with compressed air.
5. Install push rods in original positions. Apply Ford Multi-Purpose Grease D0AZ-19584-AA or equivalent to valve stem tips and push rod ends.
6. Lubricate and install the rocker arms following the procedure under Valve Rocker Arm Installation. **Ensure lower ends of push rods remain seated in valve tappets.**
7. Tighten muffler inlet pipe stud nuts to 34-52 N·m (25-38 ft-lb).
8. Install intake manifold and carburetor assembly following procedure under Intake Manifold Installation.
9. Perform Valve Clearance Check, as outlined. Adjust only if necessary.
10. If equipped with air conditioning, install compressor mounting bracket, with power steering pump in place, to LH cylinder head and water pump. Attach compressor to mounting bracket. Connect service valves and hoses to compressor.

    If not equipped with air conditioning, attach power steering pump and bracket to LH cylinder head and water pump.
11. Connect oil filler tube (E-Series and Motor Home Chassis).
12. Install Thermactor supply manifold to exhaust manifold.
13. Install bolt attaching alternator and air pump bracket to RH cylinder head. Install air pump and alternator. Adjust alternator drive belt tension. Refer to Section 27-06, Accessory Drive Belt Service.
14. Install air conditioning and power steering pump drive belt.
15. Fill and bleed cooling system. Refer to Section 27-02, Cooling System Service. Fill and bleed power steering reservoir, as necessary.
16. Connect battery(s).
17. Start engine and check for leaks.
18. If equipped with air conditioning, evacuate compressor and partially charge system with refrigerant. Refer to Section 36-30, Air Conditioning General Service.

Exhaust Manifolds

Removal

1. If removing RH exhaust manifold, remove spark plug heat shield.
2. Remove spark plug wires using Spark Plug Wire Remover T74P-6666-A or equivalent (Fig. 21).
3. Disconnect Thermactor air supply manifold.
4. Disconnect external EGR tube on LH exhaust manifold.
5. Disconnect exhaust manifold(s) at muffler inlet pipe(s).
6. Remove power steering pump support bracket (on Econoline remove brace). Remove oil dipstick tube from LH exhaust manifold.
7. Remove attaching bolts and washers. Remove exhaust manifold(s).

Inspect the cylinder head joining flanges of the exhaust manifold(s) for evidence of exhaust gas leaks.

Inspect the manifold(s) for cracks, damaged sealing surfaces, or other wear or damage that would make them unfit for further service.

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Installation

1. Clean mating surfaces of exhaust manifold(s) and cylinder head(s). Clean mounting flange of manifold(s) and inlet pipe(s). Apply light film of graphite grease to exhaust manifold(s).
2. Position exhaust manifold(s) on cylinder head(s). Install attaching bolts and washers, starting at fourth bolt hole from front of each manifold. Tighten bolts to specifications working from center of manifold to both ends (Fig. 26).
4. Position inlet pipes to manifolds. Install attaching nuts and tighten to specification. Refer to Section 26-01, General Exhaust System Service.
5. Install heat shield and spark plug wires.
6. Install air cleaner and intake duct assembly, if removed.
7. Start engine and check for exhaust leaks.

Water Pump

Removal

1. Drain cooling system. Refer to Section 27-02, Cooling System Service. Remove the fan shroud attaching bolts.
2. Remove bolts attaching fan assembly (Fig. 8) to water pumps and remove shroud and fan.
3. Remove power steering and A/C compressor (if so equipped) drive belts.
4. If vehicle is equipped with air conditioning, loosen compressor attaching bolts and remove. Remove air conditioner and power steering pump bracket.
5. Loosen alternator bolts and remove alternator and air pump drive belt. Remove air pump and bracket.
6. Loosen the bypass hose clamp at the pump.
7. Remove remaining water pump attaching bolts and remove water pump from cylinder front cover.

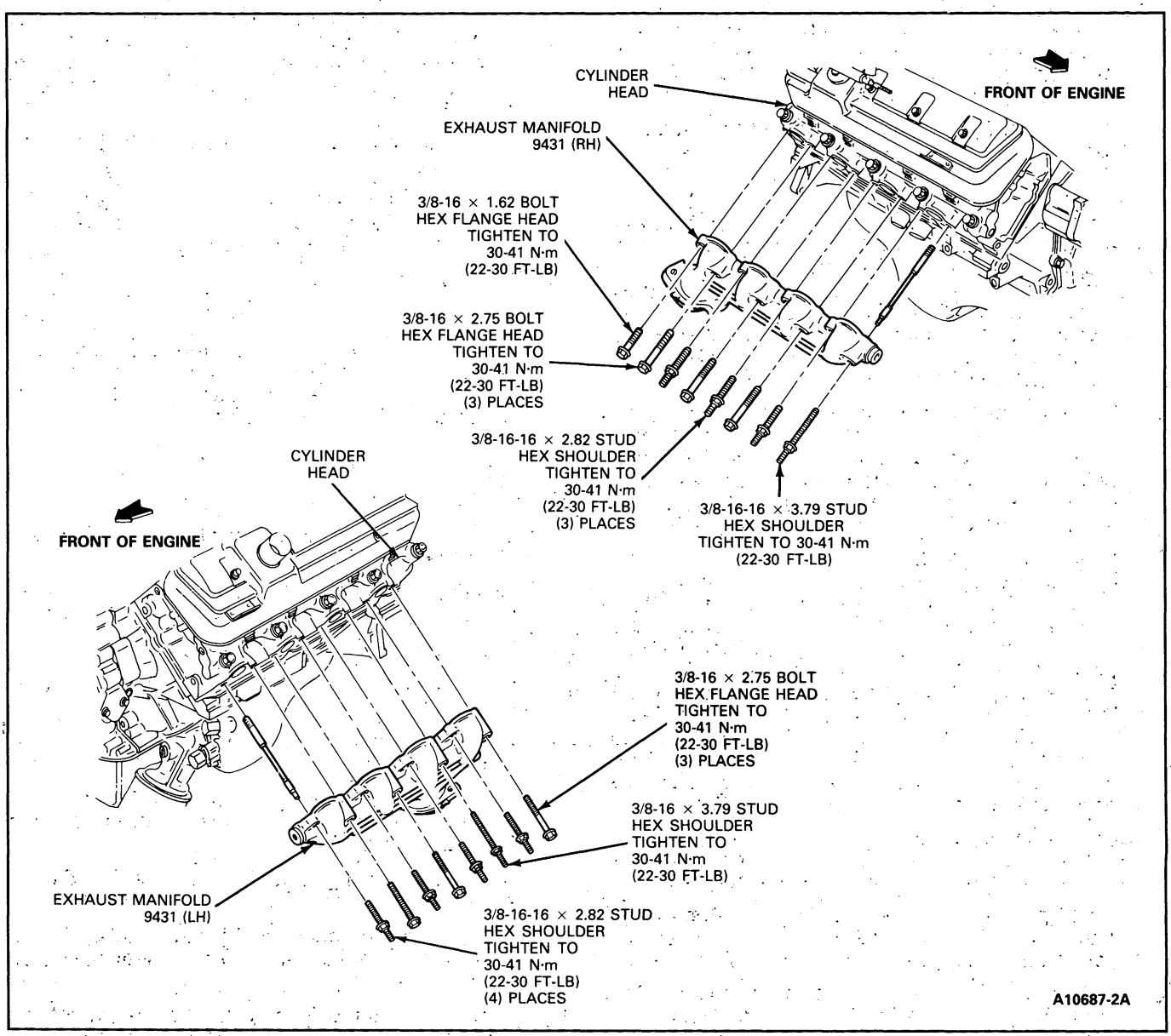


FIG. 26 Exhaust Manifold Installation

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Remove separator plate from water pump. Discard gaskets.

Installation

1. Remove any gasket material from water pump, cylinder front cover and separator plate mating surfaces.
2. Position new gaskets coated on both sides with Perfect Seal Sealing Compound B5A-19554-A or equivalent water-resistant sealer.
3. Position water pump on cylinder front cover. Install bolts and tighten to 20-28 N·m (15-21 ft-lb).
4. Install pulley on water pump. Position drive belts on their respective pulleys.
5. Connect radiator lower hose, heater return hose, and bypass hose to water pump.
6. Install air conditioner compressor bracket with power steering pump in place.
7. Rotate the alternator and air pump bracket into position and install the attaching bolts. Install air pump and alternator.
8. Lower the fan and radiator shroud into position. Refer to Section 27-04, Radiators. Install the fan (Fig. 8) attaching bolts and the shroud attaching bolts. Tighten the bolts to 16-24 N·m (12-18 ft-lb).
9. Adjust the power steering, alternator, air pump and compressor belt tension to specification. Refer to Section 27-06, Accessory Drive Belt Service.
10. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service.
11. Start the engine and check for leaks.

Front Cover and Timing Chain

Removal

Cylinder front cover oil seal replacement is recommended whenever the cover has been removed.

1. Disconnect battery(s).
2. Drain cooling system and crankcase. Refer to Section 27-02, Cooling System Service.
3. Remove screws attaching radiator shroud to radiator. Remove bolts attaching fan to water pump shaft (Fig. 8). Remove fan and radiator shroud.
4. Disconnect radiator upper and lower hoses at engine. Disconnect transmission and engine oil cooler lines at radiator, if so equipped. Disconnect engine oil cooler from radiator support and position out of the way.
5. Remove radiator upper support and remove radiator. Refer to Section 27-04, Radiators.
6. Position alternator splash shield out of the way.
7. Loosen alternator attaching bolts to relieve tension on drive belt. If equipped with air conditioning, loosen compressor idler pulley. Remove front end accessory drive hardware as outlined. Remove drive belts with water pump pulley.
8. Remove alternator, air pump and A/C compressor, if so equipped, and their respective brackets.
9. Remove the crankshaft pulley from the vibration damper.
10. Remove bolt and washer attaching crankshaft damper. Remove crankshaft damper using Crankshaft Damper Remover T58P-6316-D, or D80L-522-A or equivalent (Fig. 27). Remove Woodruff key from crankshaft.
11. Loosen bypass hose at water pump. Disconnect heater return tube at water pump.
12. Remove bolts attaching front cover to cylinder block. Remove front cover and water pump as an assembly. Discard front cover gasket and oil pan seal. Using a thin-blade knife, cut the oil pan seal flush with cylinder block face separating the cover from the cylinder block.
13. If new front cover is to be installed, remove water pump and install it and a new gasket on the new front cover.
14. Check timing chain deflection. Refer to Section 21-01, General Gasoline Engine Service.
15. If the timing chain and sprocket are to be removed, crank the engine until timing marks on sprockets are as shown in Fig. 28.
16. Remove camshaft sprocket capscrew and washer. Slide timing chain and sprockets forward, and remove as an assembly (Fig. 29).

Refer to Section 21-01, General Gasoline Engine Service for cleaning and inspection procedures.

Installation

1. Assemble the timing chain and sprockets so sprocket timing marks align with each other as shown in Fig. 28. Install the chain and sprockets as an assembly to crankshaft and camshaft. Verify proper alignment of timing marks after installation. Install front oil slinger.
2. Install the camshaft sprocket capscrew and washer. Tighten capscrew to 55-61 N·m (40-45 ft-lb). Lubricate timing chain with recommended quality engine oil. If a new chain is to be installed, submerge chain in a container of recommended quality engine oil.
3. Coat the gasket surface of the oil pan with sealer. Cut and position the required sections of a new seal on the oil pan. Apply Ford Silicone Rubber

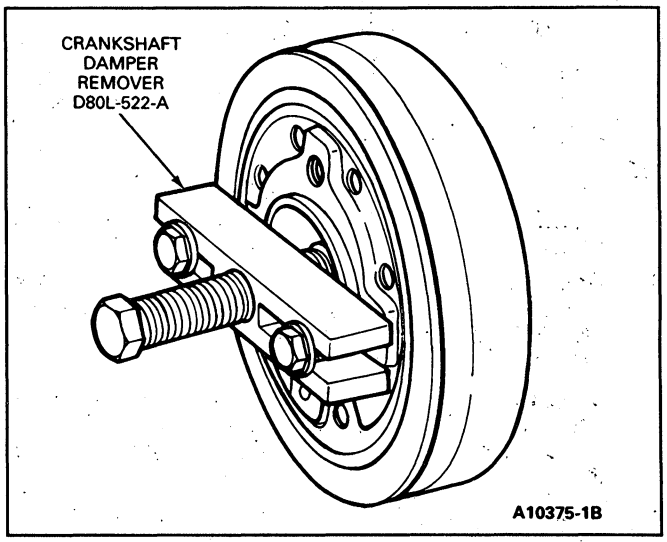


FIG. 27 Removing Crankshaft Vibration Damper

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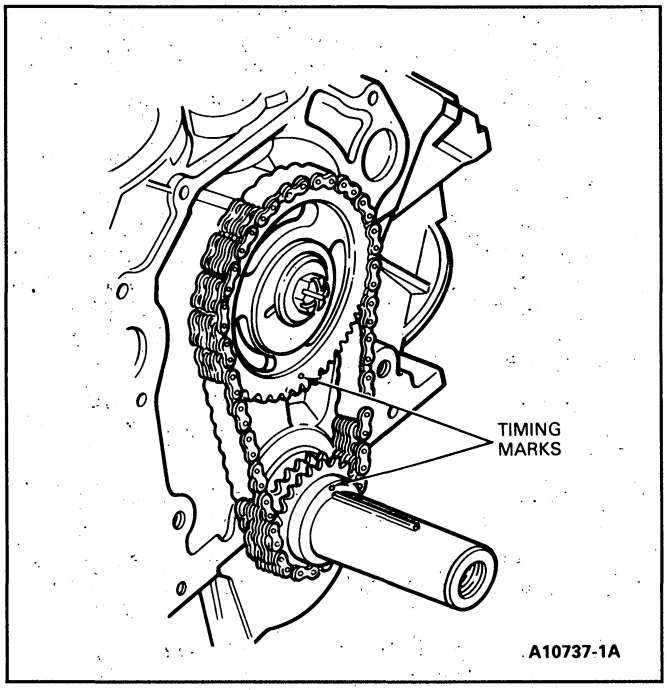


FIG. 28 Timing Mark Alignment

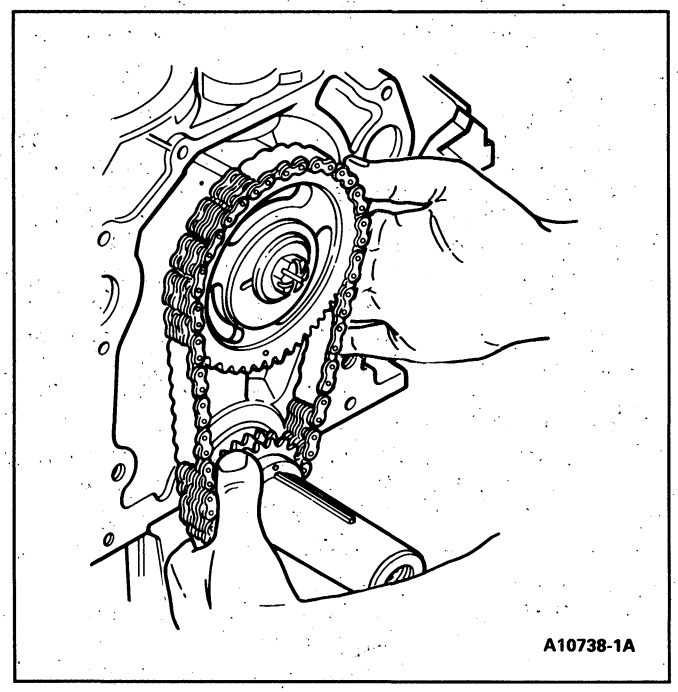


FIG. 29 Removing or Installing Timing Chain

D6AZ-19562-A (or -B) or equivalent sealer at the corners.

4. Replace front oil seal using Bearing Housing Seal Replacer T72J-1177 or equivalent (Fig. 32). After installation ensure that seal spring remains in position.
5. Coat the gasket surfaces of the block and cover with Perfect Seal Sealing Compound B5A-19554-A or equivalent sealer, and position a new gasket on the block.
6. Position the front cover onto the cylinder block. Use care when installing the cover to avoid seal damage or possible mislocation.

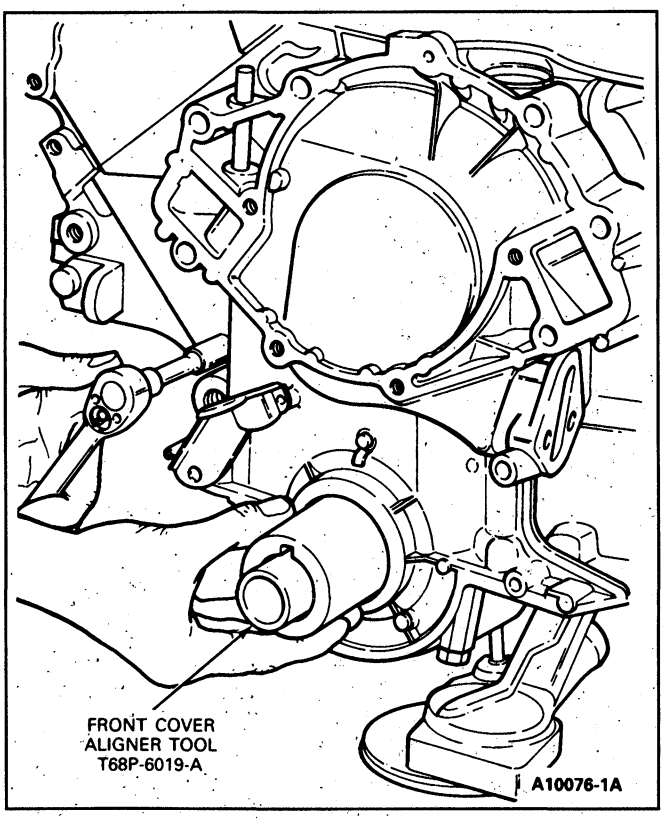


FIG. 30 Aligning Front Cover

7. Install the front cover-to-seal alignment tool into proper position (Fig. 30). It may be necessary to force the cover downward in a manner to slightly compress the pan seal. This operation can be facilitated by using a suitable tool at the attaching bolt hole locations.
8. Coat the threads of the attaching bolts with Pipe Sealant with Teflon® D8AZ-19554-A or equivalent oil-resistant sealer and install the screws.
9. While pushing in on Front Cover Aligner Tool T68P-6019-A or equivalent (Fig. 30), tighten the oil pan-to-cover attaching bolts to 10-12 N·m (9-11 ft-lb). Remove alignment tool. Tighten the cover-to-cylinder block attaching screws to 17-24 N·m (15-21 ft-lb).
10. Apply white lead and oil mixture, Ford Multi-Purpose Grease D0AZ-19584-AA or equivalent to front of crankshaft for damper installation.
11. Position crankshaft damper Woodruff key and install crankshaft damper using Crankshaft Damper and Sprocket Replacer T52L-6306-AEE or equivalent (Fig. 31). Install damper attaching screw and washer. Tighten to 95-122 N·m (70-90 ft-lb).
12. Install the crankshaft pulley and water pump pulley.
13. Install front end accessory drive hardware.
14. Install accessory drive belts and adjust belt tension to specifications. Refer to Section 27-06, Accessory Drive Belt Service. Tighten alternator attaching bolts and compressor idler pulley. Refer to Specifications.
15. Install alternator splash shield (Econoline only).
16. Position radiator to lower support. Position upper support to radiator, and install attaching bolts. Connect radiator upper and lower hoses at engine.

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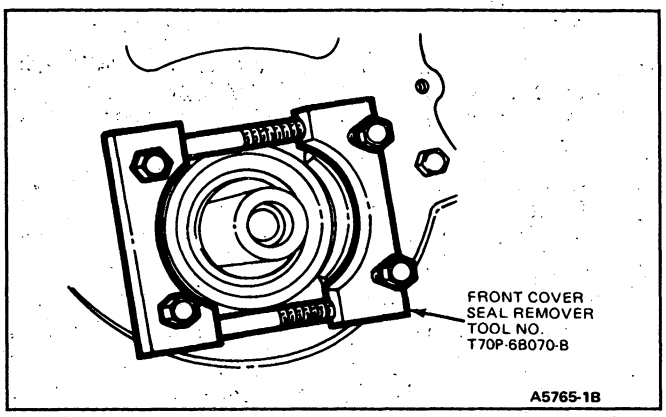


FIG. 31 Removing Front Crankshaft Seal

Connect transmission and engine oil cooler lines. Refer to Section 27-04, Radiators.

17. Place fan assembly inside radiator shroud and set in position in vehicle. Position the fan and fan spacer on the water pump pulley. Install and tighten the attaching bolts (Fig. 8). Install screws attaching shroud to radiator.
18. The crankcase oil should be drained and refilled with the proper grade and quantity of engine oil before starting the engine.
19. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service. Fill the crankcase to the correct level with the recommended oil.
20. Connect battery(s).
21. Run engine at fast idle and check for coolant and oil leaks. Adjust ignition timing to specification listed on the Vehicle Emission Control Information (VECI) decal.

Front Oil Seal

Removal

Replacement of the front oil seal is recommended whenever the front cover is removed.

Removal

1. Remove the bolts attaching the fan shroud to the radiator.
2. Remove the fan bolts from the water pump shaft. Remove the fan, spacer and shroud.
3. Loosen the alternator, power steering, Thermactor and air conditioner drive belts.
4. Remove the crankshaft pulley from the vibration damper. Remove the damper attaching screw and washer. Install the puller on the crankshaft vibration damper and remove the vibration damper.
5. Place the Front Cover Seal Remover T70P-6B070-B or equivalent onto the front cover plate over the front seal (Fig. 32). Tighten the two through bolts to force the seal puller under the seal flange.
6. Alternately tighten the four puller bolts one half turn at a time (Fig. 32). Pull the oil seal from the front cover.

Installation

1. Coat a new front cover plate oil seal with Lubriplate or equivalent and place it onto the Front Cover Seal Replacer T70P-6B070-A (Fig 33). Place the sleeve and seal onto the end of the crankshaft and push it toward the engine until the seal starts into the front cover.

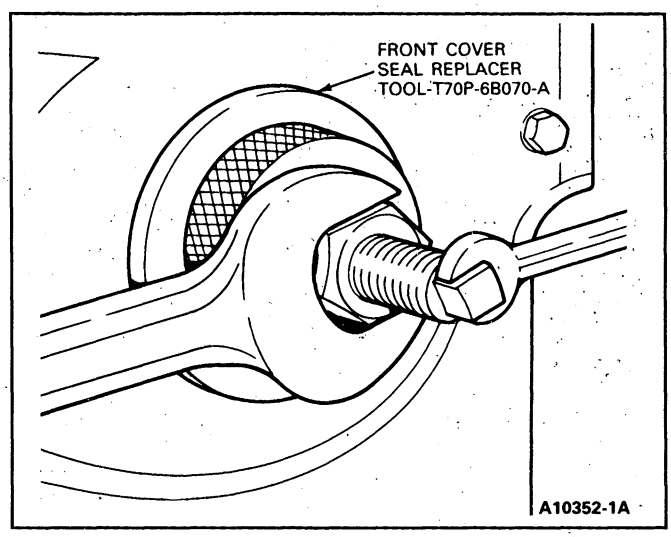


FIG. 32 Installing Front Cover Seal

2. Place the installation screw, washer, and nut onto the end of the crankshaft. Thread the screw into the crankshaft. Tighten the nut against the washer and installation sleeve to force the seal into the front cover plate. Remove the installation tool from the crankshaft.
3. Apply Lubriplate or equivalent to the oil seal rubbing surface of the vibration damper inner hub to prevent damage to the seal. Apply a white lead and oil mixture to the front of the crankshaft for damper installation.
4. Line up the crankshaft vibration damper keyway with the key on the crankshaft. Install the vibration damper on crankshaft. Install the capscrew and washer. Tighten the screw to 95-122 N·m (70-90 ft-lb). Install the crankshaft pulley.
5. Install the alternator, power steering pump, Thermactor and air conditioner belts, if so equipped.
6. Position the fan shroud over the water pump pulley. Install the fan. Install the fan shroud attaching screws.
7. Adjust the drive belts to specification. Refer to Section 27-06, Accessory Drive Belt Service.

Camshaft

Refer to Fig. 34 for the camshaft and related parts.

Removal

1. Remove cylinder front cover, timing chain and sprockets following procedure under Front Cover and Timing Chain. Check timing chain deflection before removal. Refer to Section 21-01, General Gasoline Engine Service.
2. Remove the intake manifold and throttle body as an assembly as outlined under Intake Manifold, Removal.
3. Remove valve rocker arm covers. Back off all rocker arm fulcrum bolts, turn rocker arms sideways, and remove the push rods in sequence (Fig. 24).

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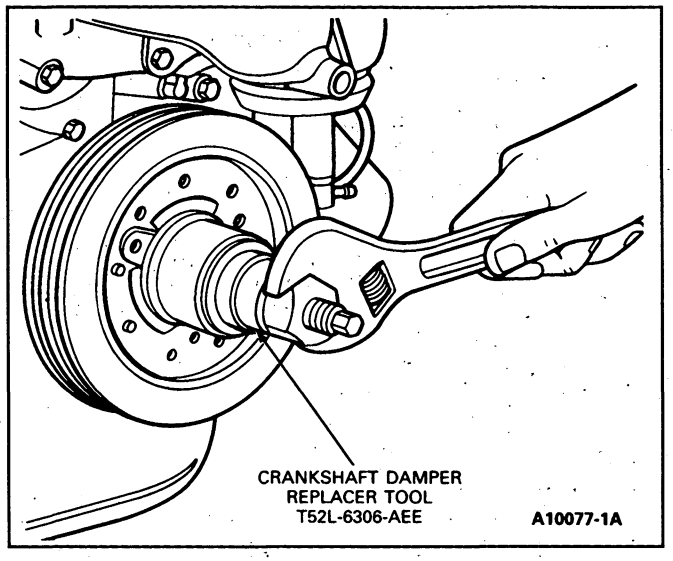


FIG. 33 Installing Crankshaft Vibration Damper

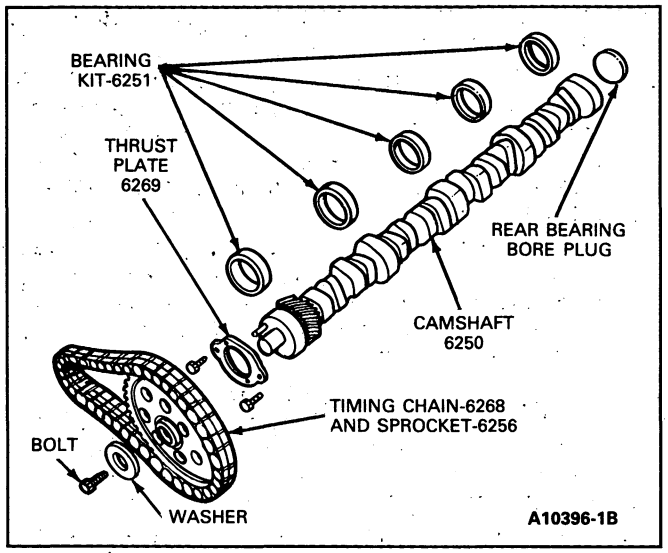


FIG. 34 Camshaft and Related Parts

4. Remove the valve tappets with a magnet and place them in a rack in sequence. If the tappets are stuck in bores, use Hydraulic Lifter Puller Tool T70L-6500-A or equivalent to remove them. Rotate the tappets back and forth to loosen them from gum or varnish deposits.

5. Remove the bolts attaching the air conditioning condenser to the chassis, if so equipped. Carefully rest the condenser on the LH fender. Secure it in this position. Refer to Section 36-65, E-150—E350 Air Conditioning System.

6. Remove the grille.

7. Remove the camshaft thrust plate attaching bolts, and carefully remove the camshaft from the front of engine. **Do not damage the camshaft bearings by nicking them with the cam lobes.**

Refer to Section 21-01, General Gasoline Engine Service for cleaning and inspection procedures, and repair as required.

Installation

1. Oil the camshaft journals and apply Ford Multi-Purpose Grease D0AZ-19584-AA or equivalent to the cam lobes. Carefully slide camshaft into position.
2. Install camshaft thrust plate. Check camshaft end play following procedure in Section 21-01, General Gasoline Engine Service. If end play is excessive, replace the camshaft thrust plate.
3. Install timing chain, sprockets, oil slinger and front cover as detailed under Front Cover and Timing Chain.
4. Position the radiator in the vehicle and install the radiator upper support to secure radiator. Refer to Section 27-04, Radiators. Connect the radiator lower hose and oil cooler lines.
5. Install the grille center support and air conditioning condenser. Refer to Section 36-65, E-150—E-350 Air Conditioning System.
6. Clean the tappets externally. Lubricate the tappets and tappet bores with specified engine oil before installing them. Lubricate the push rod ends with Ford Multi-Purpose Grease D0AZ-19584-AA or equivalent. Install the valve tappets and push rods in their original positions.
7. Install intake manifold and throttle body following the procedure under Intake Manifold, Installation.
8. Rotate the crankshaft damper until No. 1 piston is at TDC at the end of compression stroke. Install the distributor following the procedure in Section 23-01, General Ignition Service for breakerless ignition systems.
9. Apply Ford Multi-Purpose Grease D0AZ-19584-AA or equivalent to valve stem tips. Position rocker arms over push rods and tighten bolts following the procedure under Valve Rocker Arm Installation. Adjust valve clearance if necessary as outlined.
10. Clean the valve rocker arm covers and cylinder head sealing surfaces. Position new seal, if required, in cover seal groove. Ensure that the seal tang is secured in the notch of the cover.
11. Position cover on the cylinder head and tighten the four rocker arm cover bolt and washer assemblies to 8-12 N·m (6-9 ft-lb) as outlined.
12. Connect the radiator upper hose. Connect heater hose at intake manifold and at water pump.
13. Install the accelerator linkage. Install the speed control linkage, if so equipped.
14. Connect engine vacuum lines to their original outlets on the fitting at rear of the intake manifold. Connect PCV valve and hose to right valve rocker arm cover.
15. Install the distributor cap and connect the coil and spark plug wires.
16. Place the fan assembly in the radiator shroud and set in position. Position the fan assembly and fan spacer, if so equipped, to water pump hub. Install and tighten the attaching screws to specification. Install screws attaching shroud to the radiator.
17. Place the water pump pulley and drive belts in position on the water pump hub. Adjust the tension of drive belts. Refer to Section 27-06, Accessory

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Drive Belt Service. Tighten attaching screws. Refer to Specifications.

18. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service. Fill and bleed power steering reservoir. Run engine at fast idle and check for leaks.
19. Adjust the ignition timing to specifications listed on the engine decal and connect distributor vacuum line.
20. Adjust transmission linkage, if necessary. Refer to Group 16 or 17. Install the air cleaner and intake duct.

Flywheel

Removal

1. Remove the transmission from vehicle. Refer to Group 16 or 17. Remove the mounting flywheel bolts and remove flywheel from the crankshaft.

   Refer to Section 21-01, General Gasoline Engine Service for inspection.

Installation

1. Install flywheel on crankshaft. Install the mounting bolts. Tighten to 103-115 N·m (75-85 ft-lb).
2. Check flywheel runout (Fig. 35) and ring gear runout using Dial Indicator With Bracketry TOOL-4201-C or equivalent. Refer to Section 21-01, General Gasoline Engine Service. Refer to Specifications at the end of this Section.
3. Install transmission assembly into vehicle. Refer to Group 16 or 17.

Camshaft Rear Bearing Bore Plug

Removal

1. Remove the transmission from the vehicle. Refer to Group 16 or 17.
2. Remove flywheel and engine rear cover plate following procedure under Flywheel Removal.
3. Replace the plug. Refer to Section 21-01, General Gasoline Engine Service.

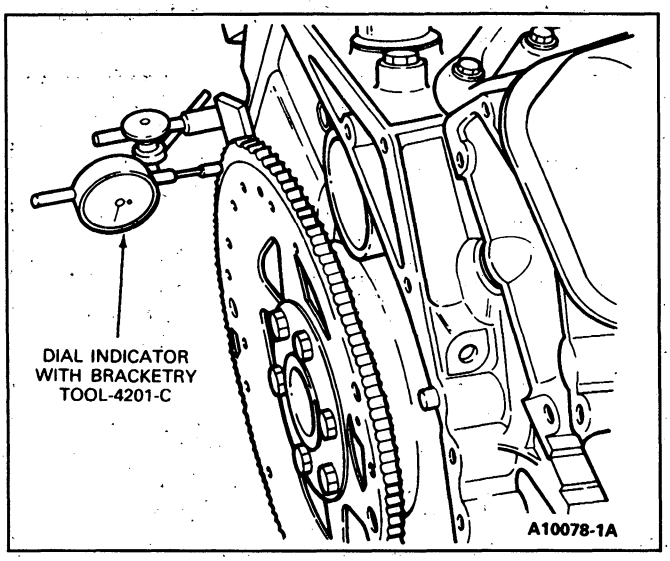


FIG. 35 Checking Flywheel Runout

Installation

1. Install the engine rear cover plate and flywheel following procedure under Flywheel Installation.
2. Install the transmission. Refer to Group 16 or 17.

Oil Pan

Removal

1. Remove the engine cover, disconnect the battery, and drain the cooling system. Refer to Section 27-02, Cooling System Service.
2. Disconnect the fresh air inlet tube and remove the air cleaner assembly. Disconnect the throttle and transmission linkage at the throttle body. Disconnect the power brake vacuum line.
3. Disconnect the fuel lines at the fuel rail, and disconnect air tubes at the throttle body.
4. Disconnect the radiator upper and lower hoses.
5. Disconnect the two transmission oil cooler lines at the radiator. Disconnect engine oil cooler lines at the filter adapter, if so equipped. Remove the fan assembly and shroud, and remove the radiator (bolts). Refer to Section 27-04, Radiators. Remove the power steering pump and position out of the way.
6. Remove the front engine mount attaching through bolts. Remove the nuts attaching the oil dipstick tube to the exhaust manifold.
7. Remove the oil filler tube and bracket (bolt).
8. If so equipped, rotate A/C lines (at rear of compressor) down to clear the dash. Remove the A/C lines if necessary.
9. Remove the upper intake manifold and throttle body as an assembly.
10. Raise the vehicle on a hoist, drain the crankcase, and remove the oil filter.
11. Remove the muffler inlet pipe assembly. Disconnect the manual and kickdown linkage from the transmission.
12. Remove the drive shaft and coupling shaft assembly. Remove the transmission dipstick tube assembly.
13. Remove the dipstick and tube from the oil pan. Place a transmission jack under the engine oil pan. Insert a wood block between the jack surface and the oil pan. Jack the engine upward, pivoting about the rear mount until the transmission contacts the floor. Then, block the engine in position at the engine mounts. The engine must remain centralized to obtain the maximum height. The engine must be raised 102mm (four inches) at the mounts to remove the oil pan.
14. Remove the oil pan retaining bolts. Lower the oil pan. Remove the oil pump and pickup tube attachments. Drop the oil pump and pickup tube assembly into the oil pan. Remove the oil pan rearward from the vehicle.

Installation

1. Clean the oil pan gasket surface at the cylinder block. Clean the oil pan assembly, the oil pump pickup tube, and the screen. Prime the oil pump by filling the inlet opening with oil and rotate the pump shaft until oil emerges from the outlet opening.

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2. Position the oil pan gaskets and end seals to the cylinder block using sealer. Position the oil pan with oil pump and pickup tube assembly to the chassis. Install the oil pump assembly to the cylinder block.
3. Position the oil pan to the cylinder block and install the attaching bolts.
4. Place jack under engine and raise engine enough to remove blocks.
5. Lower engine and remove jack.
6. Position the engine oil dipstick tube to the oil pan and exhaust manifold and install the attaching nut.
7. Re-position the A/C lines, if so equipped.
8. Install the engine support-to-bracket attaching through bolts and connect the manual kick-down linkage at the transmission. Install the drive shaft and coupling shaft assembly, and the muffler inlet pipe assembly.
9. Clean the oil filter mounting surface and install the oil filter.
10. Lower the vehicle from the hoist. Install the engine oil filler tube and bracket (one bolt). Attach the oil dipstick tube to the LH exhaust manifold (one nut).
11. Install the radiator assembly and connect the two transmission and engine oil cooler lines. Refer to Section 27-04, Radiators.
12. Install the fan assembly and shroud, and then connect the lower and upper radiator hoses.
13. Install the upper intake manifold and throttle body.
14. Connect the throttle and transmission linkage at the throttle body.
15. Re-position the power steering pump belt and adjust tension. Refer to Section 27-06, Accessory Drive Belt Service. Install the transmission filler tube to the RH cylinder head (two bolts).
16. Install the air cleaner assembly and fresh air inlet tube, fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service. Connect the battery and fill the crankcase. Start the engine and check for leaks. Install the engine cover.

Oil Pump

Remove and install the oil pump as outlined under Oil Pan Removal and Installation. The oil pump and oil pan must be removed together.

Crankshaft Rear Oil Seal

Replacement of a crankshaft rear oil seal (due to oil leakage) requires replacement of upper and lower seals. Refer to Section 21-01, General Gasoline Engine Service.

Main Bearing

Main and connecting rod bearing inserts are selective fits. Refer to Section 21-01, General Gasoline Engine Service.

Removal

1. Drain the crankcase. Remove the oil level dipstick. Remove the oil pan, oil pump and related parts following the procedure under Oil Pan Removal.
2. Replace one bearing at a time, leaving other bearings securely fastened. Remove the main bearing cap to which new bearings are to be installed.
3. Insert Main Bearing Insert TOOL-6331-E or equivalent in oil hole in crankshaft (Fig. 36).
4. Rotate the crankshaft in the direction of engine rotation to force bearing out of block.
5. Clean the crankshaft journals. Inspect journals and thrust faces (thrust bearing) for nicks, burrs or bearing pickup that would cause premature bearing wear.

Installation

1. To install upper main bearing, place plain end of bearing over shaft on locking tang side of block and partially install bearing so Main Bearing Insert TOOL-6331-E or equivalent can be inserted into oil hole in crankshaft (Fig. 36). With Main Bearing Insert TOOL-6331-E or equivalent in oil hole, rotate the crankshaft in the opposite direction of engine rotation until the bearing seats itself. Remove the tool.
2. Fit the main bearings. Refer to Section 21-01, General Gasoline Engine Service under Fitting Bearings with Plastigage.

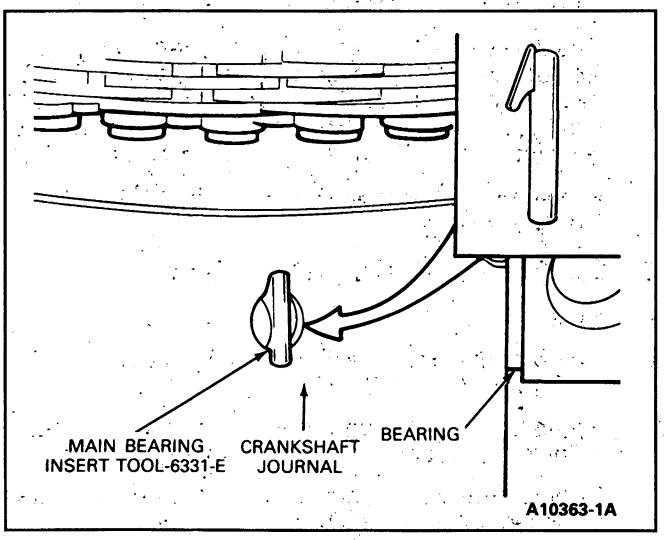


FIG. 36 Removing or Installing Upper Main Bearing Insert

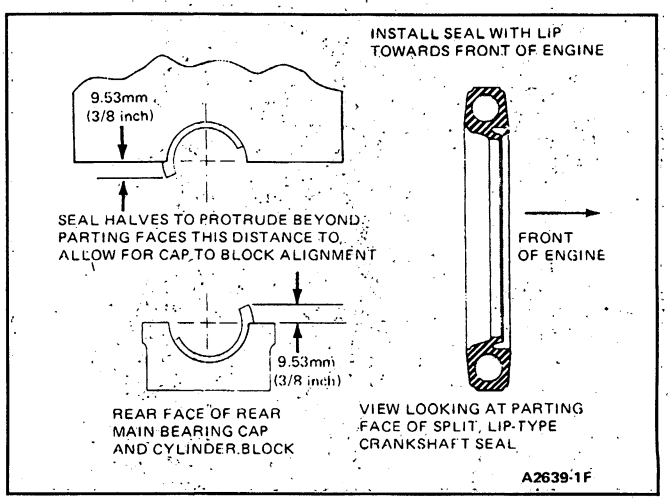


FIG. 37 Crankshaft Rear Oil Seal Installation

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3. After the bearing has been fitted, apply light coat of specified engine oil to journal and bearings. Install the bearing cap. Tighten the cap bolts to 129-142 N·m (95-105 ft-lb).

4. Repeat the procedure for remaining bearings requiring replacement.

5. If the rear main bearing is to be replaced, remove the rear main bearing cap. Remove and discard the rear oil seal.

6. Clean rear journal oil seal groove and mating surfaces of block and rear main bearing cap.

7. Install the new seal as shown in Figure 37, and according to procedure as outlined in Section 21-01, General Gasoline Engine Service.

8. Refer to Section 21-01, General Gasoline Engine Service for procedure used in sealing the rear main bearing cap. After sealing, install the rear main bearing cap. Tighten cap bolts 129-142 N·m (95-105 ft-lb).

9. If thrust bearing cap (No. 3 main bearing) has been removed, install as follows:

   Install the thrust bearing cap with bolts finger-tight. Pry the crankshaft forward against the thrust surface of upper half of bearing (Fig. 38). Hold the crankshaft forward and pry thrust bearing cap to rear. This aligns thrust surfaces of both halves of bearing. Retain forward pressure on crankshaft. Tighten cap bolts to 129-142 N·m (95-105 ft-lb).

10. Clean the oil pump inlet tube screen. Prime the oil pump by filling the inlet opening with oil and rotate the pump shaft until oil emerges from the outlet opening.

11. Install the oil pan and oil pump following procedure under Oil Pan Installation.

12. Fill the crankcase. Start the engine and check for oil pressure. Operate the engine at fast idle and check for oil leaks.

Connecting Rod Bearing

Removal

1. Drain the crankcase. Remove the oil level dipstick. Remove the oil pan, oil pump and related parts. Following the procedure under Oil Pan Removal.

2. Turn the crankshaft until connecting rod to which new bearings are to be fitted is down. Remove the connecting rod cap. Remove the bearing inserts from rod and cap.

3. Ensure bearing inserts and bearing bore in connecting rod and cap are clean. Foreign material under inserts will distort bearing and cause a failure.

4. Clean the crankshaft journal. When replacing standard bearings with new bearings, it is good practice to fit the bearing to minimum specified clearance. Refer to Specifications.

Installation

Refer to Section 21-01, General Gasoline Engine Service for cleaning and inspection procedures.

1. Fit connecting rod bearings. Refer to Section 21-01, General Gasoline Engine Service under Fitting Bearings with Plastigage.

2. Install the bearing inserts in the connecting rod and cap with tangs in the slots provided.

3. Pull the connecting rod assembly down firmly on the crankshaft journal (guide rod to prevent crankshaft journal damage).

4. Apply a light coat of specified engine oil to the journal and bearings. Install the connecting rod cap. Ensure the connecting rod bolt heads are properly seated in the connecting rod. Tighten the nuts to 55-61 N·m (45-50 ft-lb).

5. Repeat the procedure for the remaining connecting rods that require new bearings.

6. To complete installation, follow instructions under Oil Pan Installation.

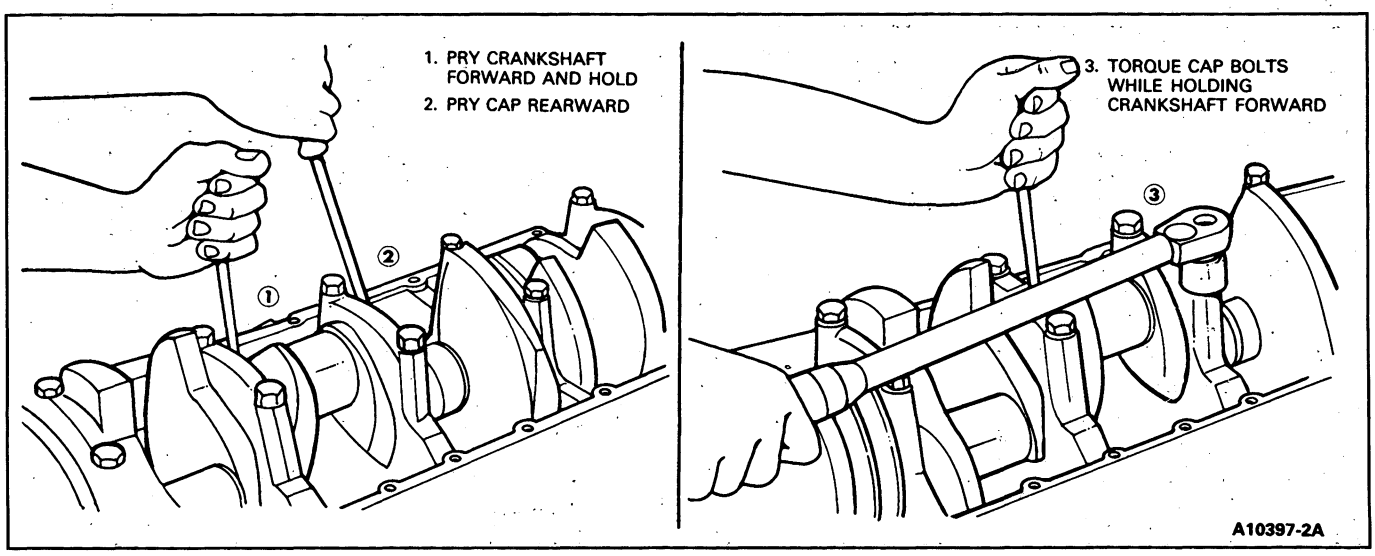


FIG. 38 Aligning Thrust Bearing

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Pistons and Connecting Rods

Removal

1. Drain the cooling system and crankcase. Refer to Section 27-02, Cooling System Service. Remove the intake manifold, cylinder heads, oil pan and oil pump as outlined.
2. Remove any ridge and/or deposits from upper end of cylinder bores as follows:

   Turn the crankshaft until the piston to be removed is at bottom of its travel. Place a cloth on top of the piston to collect cuttings. Remove any ridge and/ or deposits from the upper end of the cylinder bore. Remove the cylinder ridge with a ridge cutter. Follow instructions furnished by tool manufacturer. **Never cut into ring travel area in excess of 0.79mm (1/32 inch) when removing ridges.** Repeat the procedure at the remaining cylinders. Refer to Section 21-01, General Gasoline Engine Service.
3. Ensure all connecting rod caps are marked so they can be installed in their original positions.
4. Turn the crankshaft until the connecting rod being removed is down.
5. Remove the connecting rod nuts and cap.
6. Push the connecting rod and piston assembly out through the top of the cylinder with the handle end of a hammer. **Avoid damage to the crankshaft journal and cylinder wall when removing the piston and rod.**
7. Remove the bearing inserts from the connecting rod and cap.
8. Install the cap on the connecting rod from which it was removed.

Installation

1. If new piston rings are to be installed, remove the cylinder wall glaze. Refer to Section 21-01, General Gasoline Engine Service. Clean cylinder bores with soap and water after honing or deglazing. Dry and oil immediately after cleaning.
2. Oil the piston rings, pistons and cylinder walls with recommended quality engine oil. **Ensure to install pistons into cylinders from which they were removed or to which they were fitted. Connecting rod and bearing caps are numbered from 1 to 4 in the right bank, and 5 to 8 in the left bank, beginning at the front of engine. Numbers on the connecting rod and bearing cap must be on the same side when installed in the cylinder bore. If a connecting rod is ever transposed from one block or cylinder to another, new bearings should be fitted and the connecting rod should be numbered to correspond with the new cylinder number.**
3. Ensure ring gaps (oil ring spacer A, oil ring segments B, and compression ring C) are properly spaced around circumference of piston (Fig. 39).
4. Turn the crankshaft until the piston rod journal reaches the bottom of its stroke.
5. Install Piston Ring Compressor, D81L-6002-C or equivalent, on piston and push in with hammer handle until it is slightly below top of cylinder (Fig. 40). Ensure to guide connecting rods while tapping them into position to avoid damaging crankshaft journals. **Install piston with indentation notch in piston head toward front of engine. Push the piston down into the cylinder until the connecting rod bearings seat on the crankshaft journal.**
6. Check clearance of each bearing. Refer to procedure under Fitting Connecting Rod Bearings in Section 21-01, General Gasoline Engine Service.
7. After the bearings have been fitted, apply a light coat of recommended quality engine oil to the journals and bearings.
8. Install the connecting rod cap. Ensure connecting rod bolt heads are properly seated in the connecting rod. Tighten the nuts to 55-61 N·m (45-50 ft-lb).
9. After the piston and connecting rod assemblies have been installed, check the side clearance between the connecting rods on each crankshaft journal. Refer to Section 21-01, General Gasoline Engine Service.

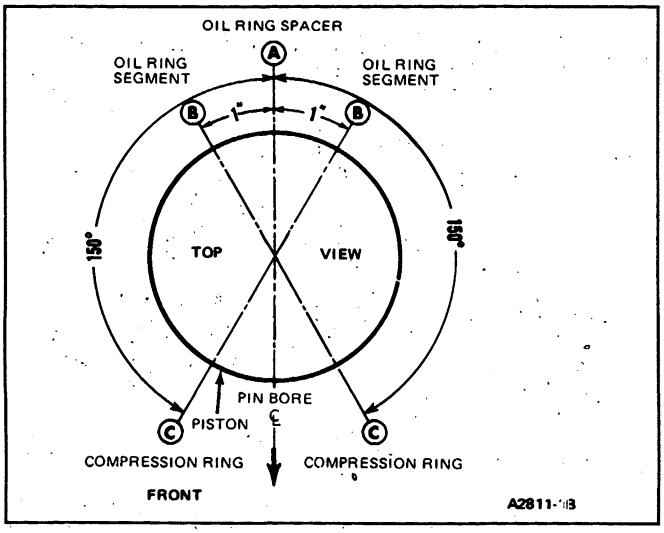


FIG. 39 Piston Ring Spacing

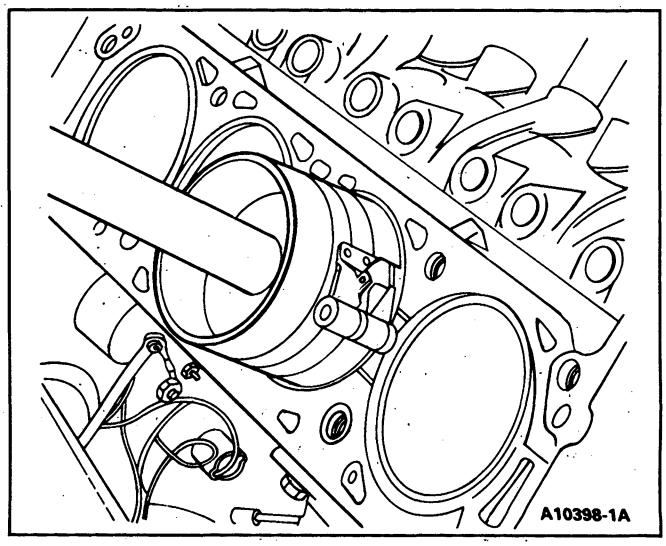


FIG. 40 Installing Piston Assembly

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10. Disassemble, clean and assemble the oil pump. Clean the oil pump inlet tube screen, oil pan, and the block gasket surfaces.
11. Prime the oil pump by filling the inlet port with engine oil and rotating the pump shaft to distribute oil within the housing. Install the oil pump and the oil pan following the procedure under Oil Pan Installation.
12. Install the cylinder heads following instructions under Cylinder Head Installation.
13. Install the intake manifold following instructions under Intake Manifold Installation.
14. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service. Fill the crankcase to the correct level with the specified engine oil.
15. Start the engine and adjust the ignition timing to specifications listed on the engine decal. Connect the distributor vacuum line.
16. Operate the engine at fast idle and check for oil and coolant leaks after the engine temperature has stabilized.
17. Install the air cleaner and intake duct assembly.

Crankshaft

To perform the following operation, it is necessary to remove the engine and install it on a work stand.

Crankshaft and related parts are shown in Fig. 41.

Removal

1. Disconnect the wires from the spark plugs using Spark Plug Wire Remover T74P-6666-A or equivalent (Fig. 21). Remove the spark plugs to allow easy rotation of crankshaft.
2. Remove the oil filter. Slide water pump bypass hose clamp toward the water pump.
3. Remove the crankshaft pulley from the vibration damper.
4. Remove the bolt and washer from the end of the crankshaft. Install Crankshaft Damper Remover T58P-6316-D or equivalent on the crankshaft vibration damper (Fig. 27) and remove damper. Remove Woodruff key.
5. Remove the cylinder front cover and water pump as an assembly. Check the timing chain deflection. Refer to Section 21-01, General Gasoline Engine Service. Remove the timing chain and sprockets as detailed in Under Front Cover and Timing Chain Removal.
6. Invert the engine on a work stand. Remove the flywheel and the engine rear cover plate. Remove the oil pan and gasket. Remove the oil pump.
7. Ensure all bearing caps, (main and connecting rod), are marked for installation into their original locations.

   Turn the crankshaft until the connecting rod from which cap is being removed is down, then remove the bearing cap. Push the connecting rod and piston assembly up into the cylinder. Repeat this procedure until all connecting rod bearing caps are removed.
8. Remove the main bearing caps.
9. Carefully lift the crankshaft out of the block so thrust bearing surfaces are not damaged. **Handle the crankshaft with care to avoid possible fracture or damage to finished surfaces.**

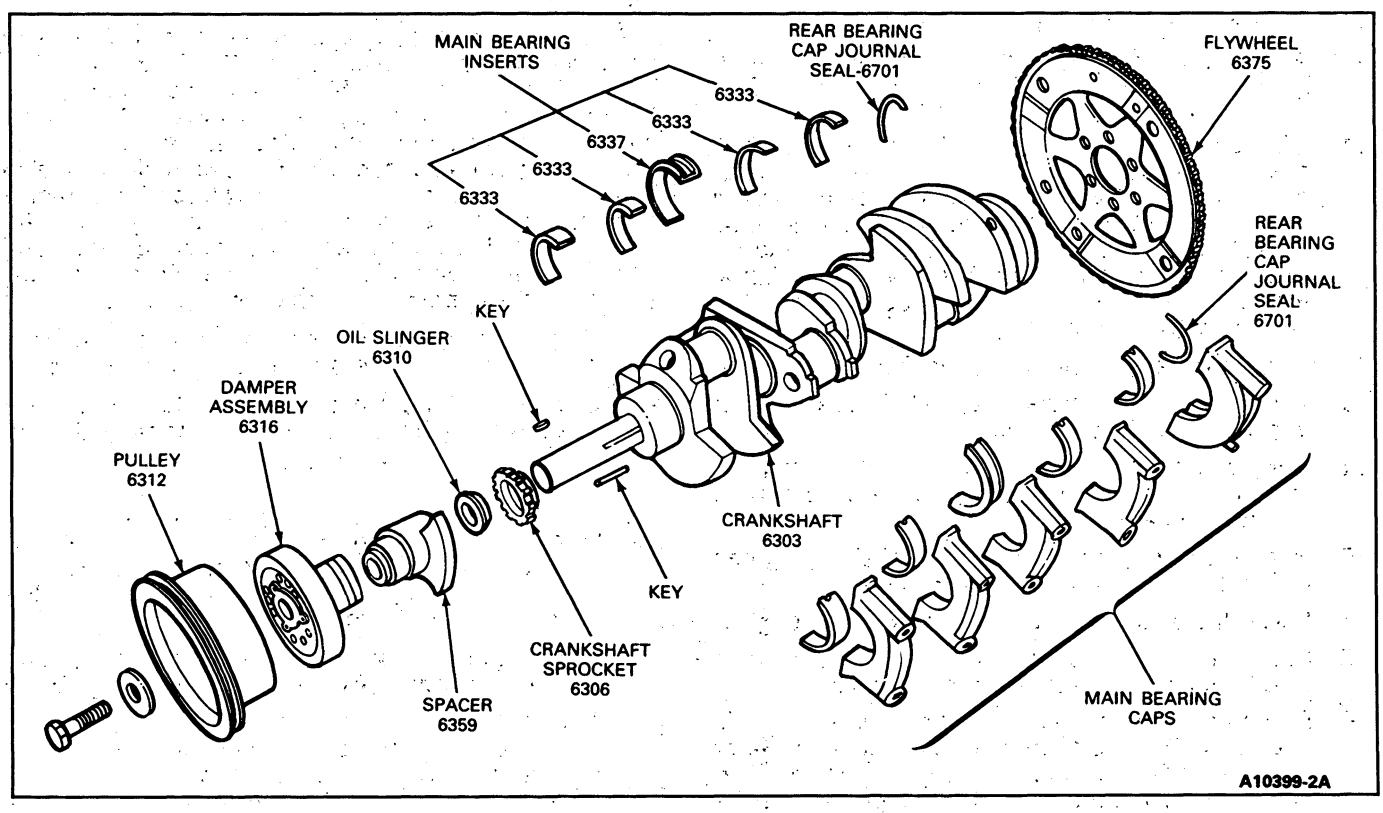


FIG. 41 Crankshaft and Related Parts

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Refer to Section 21-01, General Gasoline Engine Service for cleaning and inspection procedures. Clean the crankshaft damper.

To refinish journals and dress minor imperfections, refer to Section 21-01, General Gasoline Engine Service.

Installation

1. Remove the rear journal oil seal from block and rear main bearing cap.
2. Remove the main bearing inserts from the block and bearing caps (Fig. 41).
3. Remove the connecting rod bearing inserts from the connecting rods and caps.

   NOTE: If the original bearings are to be reused, all bearings should be marked for installation into their original locations.
4. If the crankshaft main bearing journals have been refinished to a definite undersize, install the correct undersize bearing. Ensure bearing inserts and bearing bores are clean. Foreign material under inserts will distort the bearing and cause failure.
5. Place the upper main bearing inserts in the bores with tang in slot.

   CAUTION: The oil holes in the bearing inserts must be aligned with the oil holes in the cylinder block.
6. Install lower main bearing inserts in bearing caps.
7. Clean the rear journal oil seal groove and mating surfaces of the block and rear main bearing cap.
8. Install a new rear main bearing oil seal in the block and cap. Refer to Section 21-01, General Gasoline Engine Service.
9. Carefully lower the crankshaft into place. **Be careful not to damage bearing surfaces.**
10. Check the clearance of each main bearing. Refer to Section 21-01, General Gasoline Engine Service.
11. After bearings have been fitted, apply light coat of specified engine oil to journals and bearings. Install a new seal in the rear main bearing cap and install the rear main bearing cap. Install all bearing caps except thrust bearing cap (No. 3 bearing). **Ensure main bearing caps are installed in original locations.** Tighten the bearing cap bolts to 129-142 N·m (95-105 ft-lb).
12. Install the thrust bearing cap with bolts finger-tight.
13. Pry the crankshaft forward against thrust surface of upper half of bearing (Fig. 38).
14. Hold crankshaft forward and pry thrust bearing cap to rear. This aligns the rear thrust surfaces of both halves of bearing.
15. Retain forward pressure on the crankshaft. Tighten cap bolts to 129-142 N·m (95-105 ft-lb).
16. Force the crankshaft toward the rear of engine.
17. Check the crankshaft end play. Refer to Section 21-01, General Gasoline Engine Service.
18. Install new bearing inserts in the connecting rods and caps. Check clearance of each bearing. Refer to Section 21-01, General Gasoline Engine Service under Fitting Bearings with Plastigage. Also, refer to Specifications in this Section.
19. After the connecting rod bearings have been fitted, apply light coat of specified engine oil to journals and bearings.
20. Turn the crankshaft throw to bottom of its stroke. Push the piston all the way down until rod bearing seats on the crankshaft journal. Cover rod bolt ends with section of rubber hose to prevent crankshaft journal damage during installation.
21. Install the connecting rod cap. Ensure connecting rod bolt heads are properly seated in connecting rod. Tighten nuts to 55-61 N·m (45-50 ft-lb).
22. After piston and connecting rod assemblies have been installed, check side clearance between connecting rods on each connecting rod crankshaft journal. Refer to Specifications.
23. Install timing chain and sprockets, oil slinger, damper spacer, cylinder front cover, and crankshaft damper as detailed in Front Cover and Timing Chain Installation.
24. Install the engine rear cover plate. Position flywheel on crankshaft flange. Install and tighten the bolts to 103-115 N·m (75-85 ft-lb).
25. Clean the oil pan, oil pump and oil pump screen. Prime the oil pump by filling inlet port with engine oil and rotating pump shaft to distribute oil within housing. Install oil pump and oil pan by following procedures under Oil Pan Installation.
26. Install the oil filter, and connect the fuel lines.
27. Install the spark plugs and connect the spark plug wires.
28. Install the engine in vehicle as outlined.

Clutch Pilot Bearing

Removal

A needle roller bearing and adapter assembly is used as a clutch pilot bearing on E-150—E-350, F-150—F-350, F-Super Duty and Bronco vehicles (Fig. 42). It is inserted directly into the engine crankshaft. The bearing and adapter assembly comprises an assembly that cannot be serviced separately. The assembly must also be replaced as a unit. The clutch pilot bearing can only be installed with the seal end of the bearing facing the transmission. The bearing and seal are pre-greased and do not require additional lubrication. A new bearing must be installed whenever a bearing is removed.

1. Remove the transmission and flywheel housing, clutch pressure plate and disc. Refer to Group 16.
2. Use Impact Slide Hammer T59L-100-B and Puller Attachment T58L-101-B (Fig. 43) or equivalent to remove the pilot bearing.

Installation

1. Using Pilot Bearing Replacer T74P-7137-A or equivalent, install the pilot bearing with the seal facing the transmission (Fig. 44) so that the adapter is not cocked.
2. Install the clutch pressure plate, disc, and transmission and flywheel housing. Refer to Group 16.

   NOTE: Care must be taken not to damage the bearing during transmission installation while the transmission input shaft is being inserted into the bearing.

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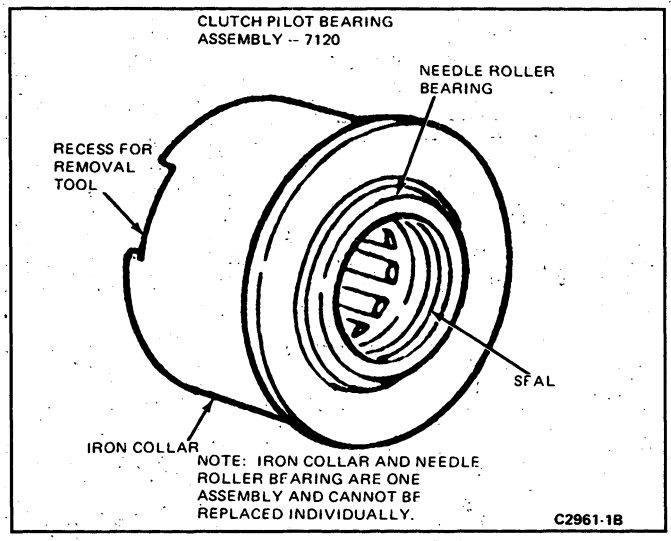


FIG. 42 Clutch Pilot Bearing Assembly

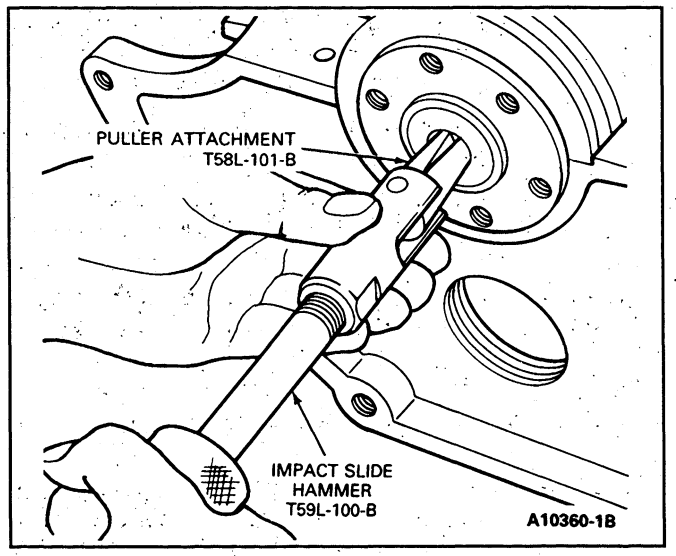


FIG. 43 Removing Clutch Pilot Bearing Assembly

Camshaft Bearings

Camshaft bearings are available prefinished to size for standard and undersize journal diameters.

Removal

1. With engine removed and placed in a work stand, remove the camshaft, flywheel, and crankshaft as outlined. Push pistons to top of cylinders.
2. Remove the camshaft rear bearing bore plug. Refer to Section 21-01, General Gasoline Engine Service.
3. Select the proper size expanding collet and backup nut and assemble onto expanding mandrel. With the expanding collet collapsed, install the collet in the camshaft bearing. Tighten backup nut on expanding mandrel until collet fits camshaft bearing.
4. Assemble the puller screw and extension, if necessary, as shown in Fig. 45 and install on expanding mandrel. Wrap a cloth around threads of the puller screw to protect the front bearing or journal. Tighten pulling nut against the thrust bearing and pulling plate to remove camshaft bearing. Hold a wrench on the end of puller screw to prevent it from turning.
5. Repeat the procedure for each bearing. To remove the front bearing, install puller screw from rear of cylinder block.
6. Position new bearings at bearing bores, and press in place with the tool shown in Fig. 44. Ensure to center the pulling plate and puller screw to avoid bearing damage.

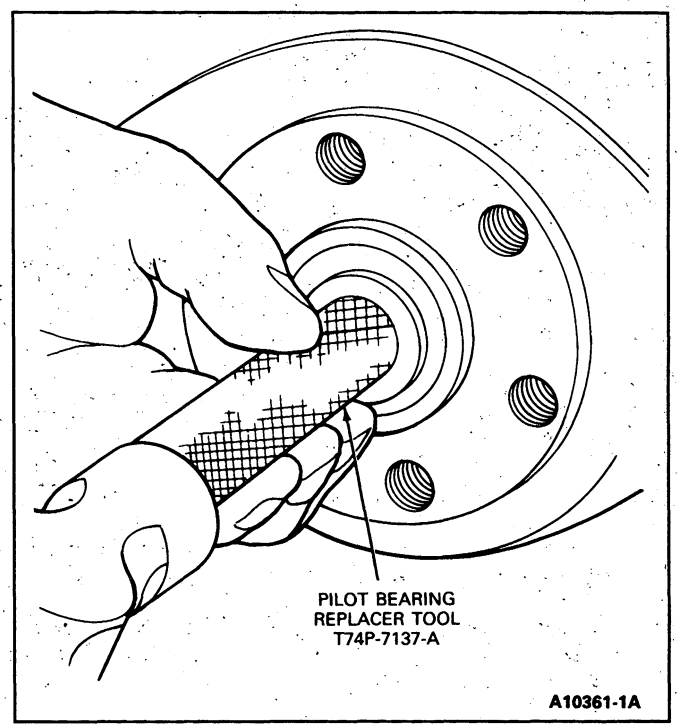


FIG. 44 Installing Clutch Pilot Bearing

CAUTION: Failure to use correct expanding collet can cause severe bearing damage. Align oil holes in bearings with oil holes in cylinder block before pressing them into block. Ensure front bearing is installed 0.054-0.081mm (0.040-0.060 inches) below front face of cylinder block (Fig. 46).

7. Install the core plug. Refer to Section 21-01, General Gasoline Engine Service.
8. Install the camshaft, crankshaft, flywheel and related parts as outlined. Do not check connecting rod and main bearing clearances.

Oil Filter

Removal

The oil filter and adapter assembly is shown in Fig. 47.

1. Place a drip pan under the filter. Unscrew the filter from the adapter fitting using an oil filter wrench. Clean the adapter recess. Clean the oil filter gasket surface.

Installation

1. Coat the gasket on a new filter with specified engine oil. Place a new filter on the adapter fitting. Hand tighten the filter until the gasket contacts the sealing surface, then tighten another one-half turn.
2. Add one quart of oil. Operate the engine at fast idle and check for oil leaks. If oil leaks are evident,

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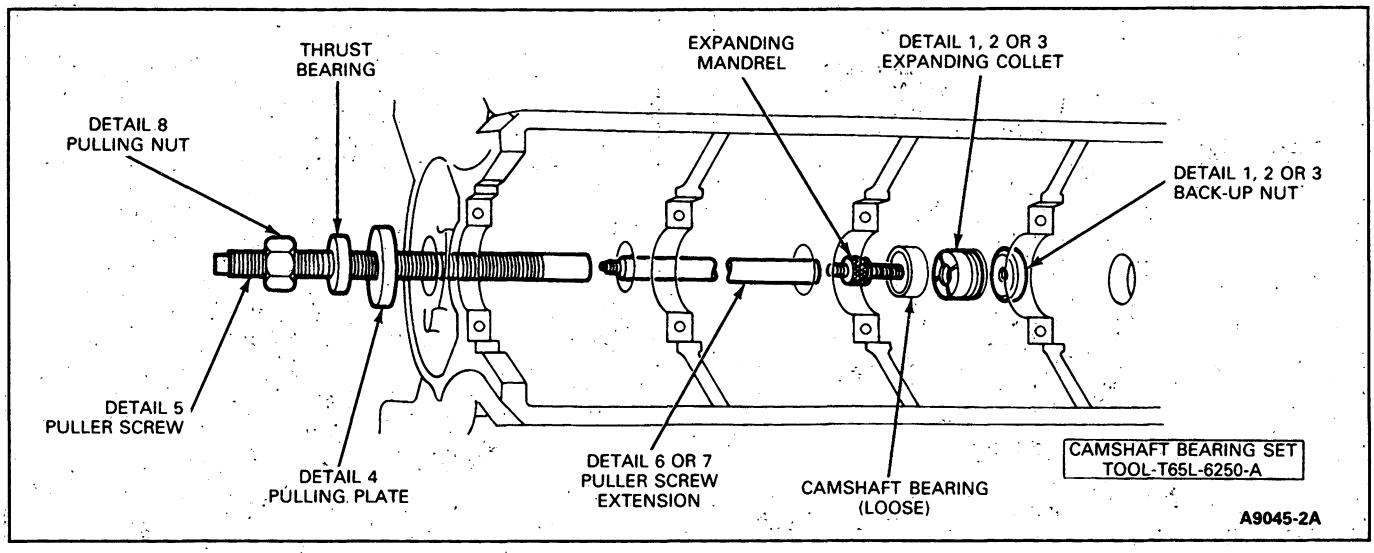


FIG. 45 Replacing Camshaft Bearing

perform the necessary repairs to correct the leakage. Check the oil level and fill the crankcase to the correct level.

DISASSEMBLY AND ASSEMBLY

When installing nuts or bolts that must be tightened, oil the threads with light engine oil. Refer to Specifications for proper torque values. **Do not oil threads requiring oil-resistant or water-resistant sealer.**

Valve Tappet

Each tappet is a matched assembly. If parts of one are mixed with those of another, improper valve operation may result. Disassemble and assemble each tappet separately. Valve tappets should be tested after assembly. Refer to Section 21-01, General Gasoline Engine Service. Keep the tappet assemblies in proper sequence so they can be installed in their original bores.

Disassembly

Refer to Fig. 48.

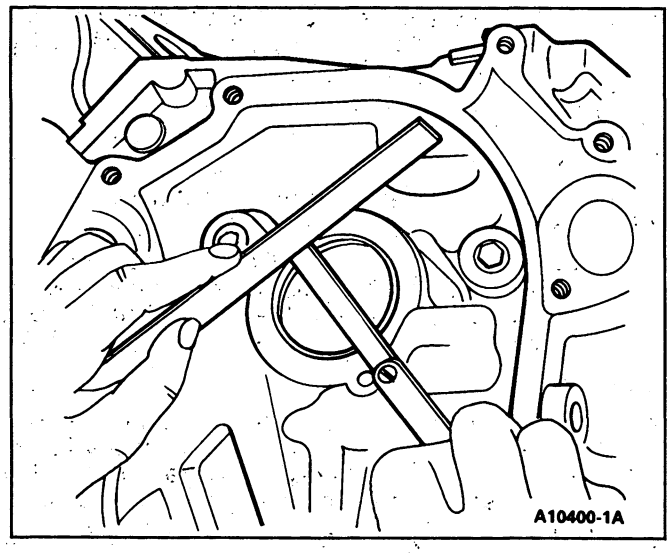


FIG. 46 Measuring Depth of Camshaft Front Bearing

1. Grasp the lock ring with needlenose pliers to release it from the groove. It may be necessary to depress the plunger to fully release lock ring.
2. Remove the push rod cup, metering valve (disc), and plunger assembly.
3. Carefully remove the plunger spring, check valve retainer spring, check valve retainer and check valve disc from the plunger.

Refer to Section 21-01, General Gasoline Engine Service for cleaning and inspection procedures.

Assembly

1. Place the plunger upside down on a clean work bench.
2. Place the check valve (disc or ball check) in position over the oil hole on the bottom of the

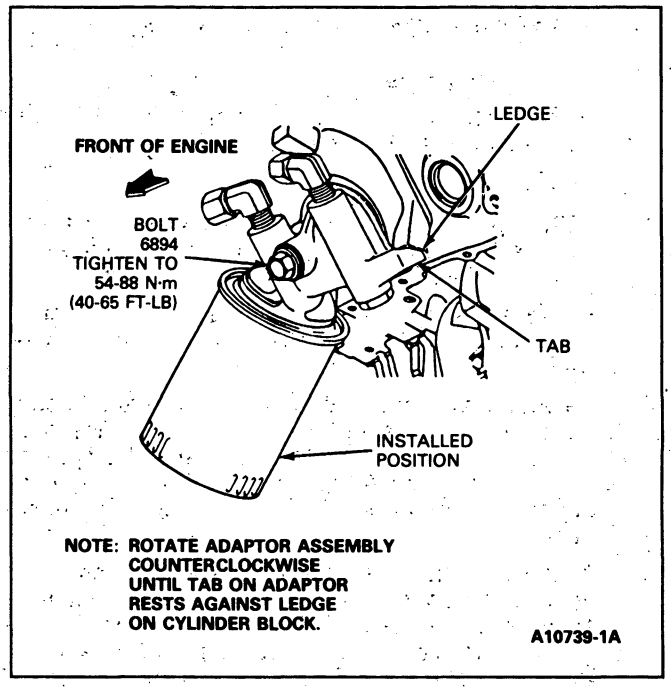


FIG. 47 Oil Filter

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plunger. Set the check valve spring on top of the check valve (disc or ball check).

3. Position the check valve retainer over the check valve and spring. Then, push the retainer down into place on the plunger.
4. Place the plunger spring and the plunger (open end up) into tappet body.
5. Position the metering valve (disc) in the plunger, and place push rod seat in the plunger.
6. Depress the plunger and position the closed end of lock ring in the groove of the tappet body. With the plunger still depressed, position the open ends of lock ring in the groove. Release the plunger, and then depress it again to fully seat the lock ring.
7. Use Leak Down Tester TOOL-6500-E or equivalent, to fill the tappet with test fluid. Refer to Section 21-01, General Gasoline Engine Service.

Cylinder Head

Disassembly

1. With cylinder head removed from engine, remove rocker arm fulcrum bolts, oil deflectors, fulcrum seats, and rocker arms. Remove exhaust manifolds and spark plugs.
2. Clean carbon from combustion chambers before removing valves.
3. Compress valve springs using Valve Spring Compressor T70P-6049-A or equivalent. Remove spring retainer locks and release springs. Remove retainers, springs, stem seals, and valves. Discard stem seals.

   Clean and inspect cylinder head(s) and related components. Refer to Section 21-01, General Gasoline Engine Service

   Refer to Section 21-01 for cylinder head and valve repair procedures.

Assembly

Lubricate all valves, valve stems and valve guides with specified engine oil. Apply Ford Multi-Purpose Grease D0AZ-19584-AA or equivalent to the valve tips before installation.

1. Install each valve in the port from which it was removed or to which it was fitted. Install new valve stem seal on each valve. NOTE: Ensure the proper seal application for intake and exhaust are in place.
2. Set valve spring and retainer over valve stem. Compress spring and install retainer locks.
3. With dividers, measure assembled height of valve spring from surface of spring pad on cylinder head to underside of spring retainer (Fig. 49). Check dividers with accurate scale. If assembled height exceeds specification, install spacer(s) below spring to reduce height to recommended dimension. Refer to Specifications. **Reducing assembled height below specifications can cause spring breakage and rapid wear of cam lobe.**
4. Coat the fulcrum seats and sockets with Ford Multi-Purpose Grease D0AZ-19584-AA or equivalent. Ensure the rocker arm fulcrum bolts are in a serviceable condition before installing them. Install rocker arms, fulcrum seats, oil deflectors and fulcrum bolts as outlined under Valve Rocker Arm Installation.
5. Install exhaust manifolds and spark plugs as outlined.

Piston and Connecting Rod

Disassembly

1. Remove the bearing inserts from the connecting rod and cap.
2. Mark the pistons to ensure assembly with same rod and installation in the same cylinders from which they were removed.
3. Using an arbor press and Piston Pin Remover/ Replacer T68P-6135-A or equivalent shown in Fig. 48, press the piston pin from the piston and connecting rod. Remove the piston rings.

   Refer to Section 21-01, General Gasoline Engine Service for cleaning and inspection procedures. Repair if required.

Assembly

Check the fit of a new piston in the cylinder bore before assembling piston and piston pin to connecting rod. Piston pin bore of connecting rod

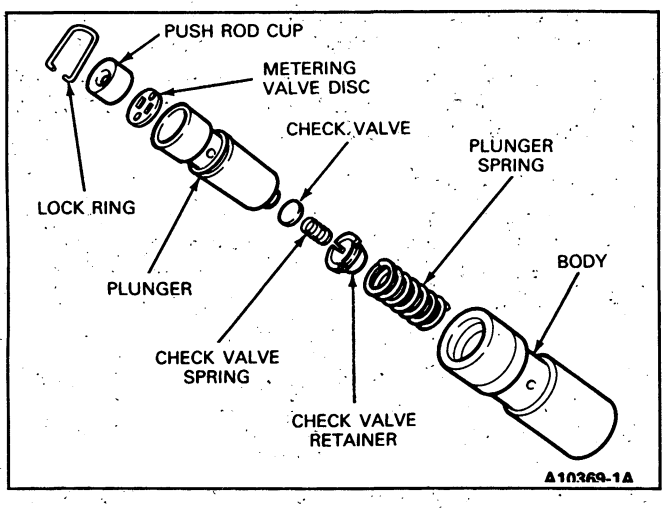


FIG. 48 Hydraulic Valve Tappet

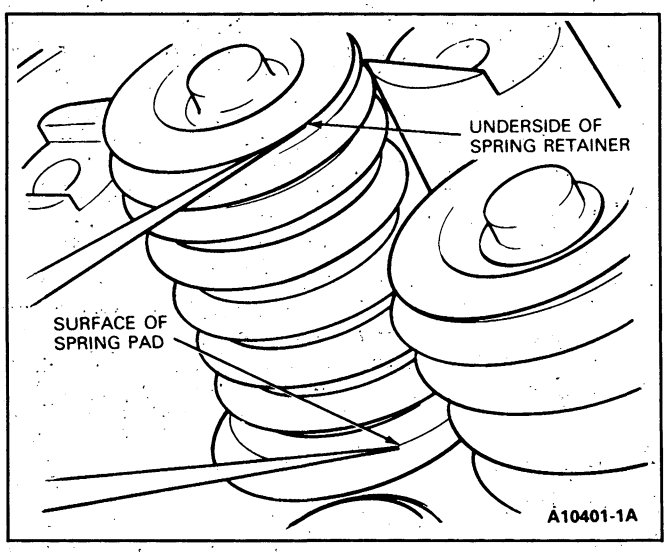


FIG. 49 Measuring Valve Spring Assembled Height

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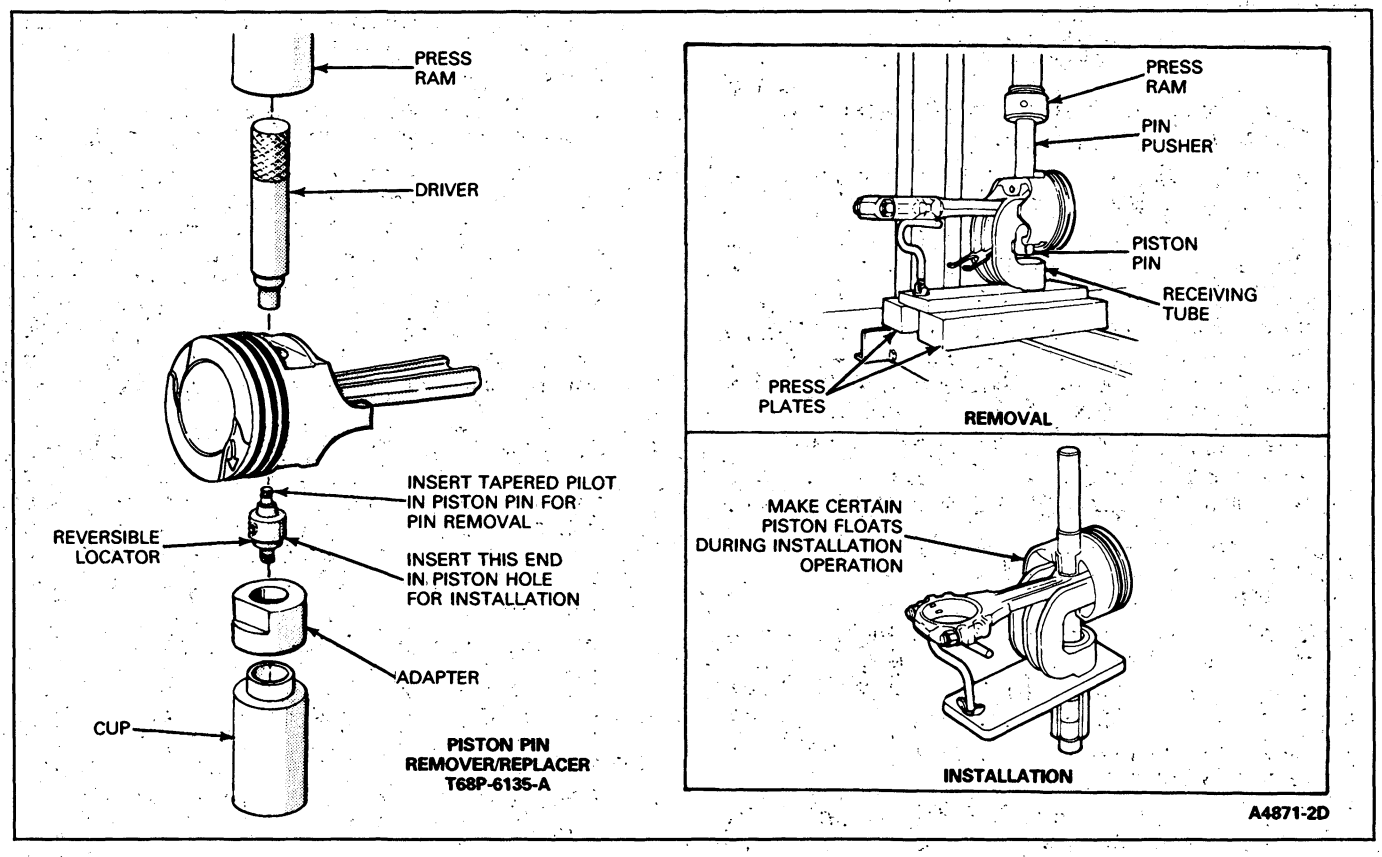


FIG. 50 Removing or Installing Piston Pin

and diameter of piston pin must be within specifications.

1. Apply a light coat of specified engine oil to all parts. Assemble the piston to the connecting rod with the cylinder number side of the connecting rod and indentation notch in piston positioned as shown in Fig. 51.
2. Start the piston pin in the piston and the connecting rod. Using an arbor press, press the piston pin through the piston and connecting rod until the end of pin is 1.59-3.18mm (1/16-1/8 inch) below chamfer of the pin bore in the piston.
3. Check the end gap of all piston rings. End gap must be within specifications. Follow the instructions contained on piston ring package and install the piston rings.
4. Check the ring-side clearance of compression rings with a feeler gauge inserted between the ring and the lower land. Feeler gauge should slide freely around the ring circumference without binding. Any wear will form a step at the inner portion of the lower land. **If the lower lands have high steps, replace the piston.**
5. Ensure the bearing inserts and bearing bore in the connecting rod and cap are clean. Foreign material under the inserts will distort the bearing and cause failure. Install bearing inserts in connecting rod and cap with tangs fitting in slots provided.

Cylinder Assembly—6009

Disassembly

1. Mount the old engine on a work stand and remove all the parts not furnished with the new cylinder assembly, following the procedures given in Removal and Installation of this Section.
2. Remove the 4 cylinder head locating dowels and the block drain plugs.
3. Remove the old cylinder assembly from the work stand.

Assembly

1. Clean the gasket and seal surfaces of all serviceable parts and assemblies.
2. Position the new cylinder assembly on a work stand and install the cylinder head locating dowels and block drain plugs.
3. Transfer all serviceable parts removed from the old cylinder assembly, following the procedures given in Removal and Installation of this Section.
4. Check all assembly clearances following specifications listed at the end of this Section and correct as necessary.

Cylinder Block—6010

Before replacing a cylinder block, determine if it is repairable. If so, make the necessary repairs, following the procedures given in Section 21-01, General Gasoline Engine Service.

Disassembly

1. Mount the old engine in a work stand and completely disassemble it, following the procedures given in Removal and Installation of this Section.
2. Ensure that cylinder bores are ridge-reamed before removing piston assemblies, if required.

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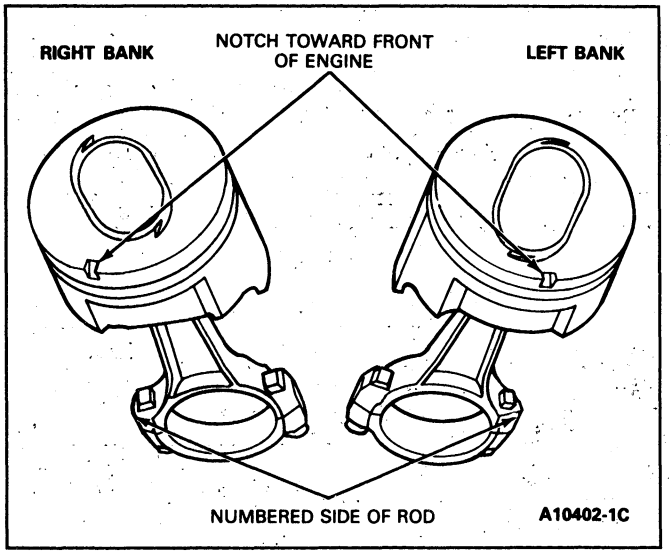


FIG. 51 Correct Piston and Rod Positions

3. Remove the cylinder head locating dowels and the block drain plugs.

Assembly

1. Clean the gasket and seal surfaces of all serviceable parts and assemblies.
2. Position the new cylinder block in a work stand and install the cylinder head locating dowels and the block drain plugs.
3. Transfer all serviceable parts removed from the old cylinder block, following applicable procedures under Removal and Installation in this Section.
4. Check all assembly clearances following specifications at the end of this Section and correct as necessary.

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SPECIFICATIONS

GENERAL SPECIFICATIONS

Engine	Bore and Stroke	Firing Order	Oil Pressure Hot @ 2000 RPM kPa (PSI)	Engine Type and Number of Cylinder
7.5L (460 CID) V-8	4.36 x 3.85	15426378	276-448 (40-65)	O.H.V. V-8

CYLINDER HEAD

Engine	Combustion Chamber Volume C.C. ③	Valve Guide Bore Diameter		Valve Seat Width ①		Valve Seat Runout TIR Maximum	Valve Arrangement Front to Rear	Gasket Surface Flatness ②
		Intake	Exhaust	Intake	Exhaust			
7.5L (460 CID) V-8	95.7-98.7	.3433-.3443	.3433-.3443	.060-.080	.060-.080	.002	RT I-E-I-E-I-E-I-E LT E-I-E-I-E-I-E-I	.003 in any 6 in. .006 overall

① Valve seat angle — 45°.
② Gasket surface finish — RMS 60-150.
③ Compression pressure (PSI) of the lowest cylinder must be at least 75% of the highest to be within specification.

VALVE ROCKER ARM SHAFT, PUSH RODS AND TAPPETS

Engine	Rocker Arm Lift Ratio to 1	Push Rod Runout TIR Maximum	Valve Tappet or Lifter			Collapsed Tappet Gap (Clearance)	
			Standard Diameter	Clearance to Bore ①	Hydraulic Lifter Leakdown Rate ②	Allowable	Desired
7.5L (460 CID) V-8	1.73	.015	.8740-.8745	.0007-.0027	10 to 50 seconds for 1/16 travel	.075-.175	.100-.150

① Service limit — .005.
② Time required for plunger to leakdown .0625 in. under load of 50 lbs. using leakdown fluid in tappet.

VALVE SPRINGS

Engine	Valve Spring Compression Pressure Lbs. @ Specified Height		Valve Spring Free Length (Approximate)		Valve Spring Assembled Height		Valve Spring Out of Square Maximum
	Intake ①	Exhaust	Intake	Exhaust	Intake	Exhaust	
7.5L (460 CID) V-8	76-84 @ 1.81 218-240 @ 1.33	76-84 @ 1.81 218-240 @ 1.33	2.06	2.06	1-51/64 — 1-53/64	1-51/64 — 1-53/64	5/64 (.078)

① Service limit — 10% loss of pressure.

VALVES

Engine	Valve Stem to Guide Clearance ①		Valve Head Diameter ②		Valve Face Runout TIR Maximum
	Intake	Exhaust	Intake	Exhaust	
7.5L (460 CID) V-8	.0010-.0027	.0010-.0027	1.965-1.989	1.646-1.661	.002

① Service clearance — .0055.
② Valve face angle — 44°.

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VALVES (Continued)

Engine	Standard		Valve Stem Diameter .015 Oversize		.030 Oversize	
	Intake	Exhaust	Intake	Exhaust	Intake	Exhaust
7.5L (460 CID) V-8	.3415-.3423	.3415-.3423	.3565-.3573	.3565-.3573	.3715-.3723	.3715-.3723

CAMSHAFT

Engine	Lobe Lift ①		Camshaft End Play		Camshaft Journal to Bearing Clearance ②
	Intake	Exhaust	End Play	Service Limit	
7.5L (460 CID) V-8	.252	.278	.001-.006	.009	.001-.003

① Maximum allowable lift loss — .005.
② Service limit — .006.

CAMSHAFT DRIVE

Engine	Camshaft Journal Diameter — Standard ①					Camshaft Bearing Inside Diameter					Camshaft Front Bearing Location ②	Timing Chain Deflection Inches Maximum
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 1	No. 2	No. 3	No. 4	No. 5		
7.5L (460 CID) V-8	2.1238-2.1248	2.1238-2.1248	2.1238-2.1248	2.1238-2.1248	2.1238-2.1248	2.1258-2.1268	2.1258-2.1268	2.1258-2.1268	2.1258-2.1268	2.1258-2.1268	.040-.060	.500

① Camshaft journal runout — .005 TIR maximum.
② Distance in inches that front edge of the bearing is installed below the front face of the cylinder block.

CYLINDER BLOCK

Engine	Cylinder Bore Diameter ①	Main Bearing Bore Diameter	Distributor Shaft Bearing Bore Diameter	Head Gasket Surface Flatness	Head Gasket Surface Finish	Tappet Bore Diameter
7.5L (460 CID) V-8	4.3600-4.3636	3.1922-3.1934	.5160-.5175	.003 in any 6 in. .006 overall	RMS 90-150	.8752-.8767

① Maximum out-of-round — .0015, Service limit — .005, Maximum taper service limit — .010, Cylinder bore surface finish RMS 18-38, Bore taper service limit — .010

CRANKSHAFT AND FLYWHEEL

Engine	Main Bearing Journal Diameter ①	Main Bearing Journal Runout TIR Maximum ②	Main Bearing Thrust Face Runout TIR Maximum	Main Bearing Journal Taper Maximum Per Inch	Thrust Bearing Journal Length	Main and Rod Bearing Journal Finish RMS Maximum	Main Bearing Thrust Face Finish RMS Maximum
7.5L (460 CID) V-8	2.9994-3.0002	.002	.001	.0005	1.124-1.126	12	25 Front — 23 Rear

① Maximum out-of-round — .0006.
② Service limit — .005.

CRANKSHAFT AND FLYWHEEL (Continued)

Engine	Connecting Rod Journal Diameter ②	Connecting Rod Journal Taper Per Inch Maximum	Crankshaft Free End Play ②
7.5L (460 CID) V-8	2.4992-2.5000	.0006	.004-.008

① Maximum out-of-round — .0006.
② Service limit — .012.

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CRANKSHAFT BEARINGS

Engine	Connecting Rod Bearing to Crankshaft Clearance Selective Fit			Main Bearing to Crankshaft Clearance Selective Fit		
	Desired	Allowable	Bearing Wall Thickness Std. ①	Desired	Allowable	Bearing Wall Thickness Std. ①
7.5L (460 CID) V-8	.0008-.0015	.0008-.0025	.0757-.0762	.0008-.0015	.0008-.0026	.0955-.0960

① For .002 undersize add .001 to standard wall thickness.

CONNECTING ROD

Engine	Piston Pin Bore or Bushing I.D.	Rod Bearing Bore I.D. ①	Rod Length Center to Center	Connecting Rod Alignment Maximum Total Difference		Rod to Crankshaft Assembled Side Clearance ③
				Twist ②	Bend ②	
7.5L (460 CID) V-8	1.0386-1.0393	2.6522-2.6530	6.6035-6.6065	.024	.012	.010-.020

① Connecting rod bearing bore maximum out-of-round — .0004.
② Pin bushing and crankshaft bore must be parallel and in same vertical plane within specified total difference when measured at the ends of an 8-inch long bar, 4 inches on each side of rod centerline.
③ Service limit — .023.

PISTON

Engine	Diameter ①			Piston to Bore Clearance Selective Fit	Piston Pin Bore Diameter	Ring Groove Width Compression		
	Coded Red	Coded Blue	.003 Oversize			Top	Bottom	Oil
7.5L (460 CID) V-8	4.3577-4.3583	4.3589-4.3595	4.3601-4.3607	.0022-.0030	1.0401-1.0406	.0805-.0815	.0805-.0815	.188-.189

① Measured at the piston pin bore centerline at 90° to the pin.

SERVICE PISTON SELECTION

Piston Bore Diameter	I.D. Code of Service Piston Required
110.744-110.774 mm (4.3600-4.3612 in.)	Red
110.774-110.805 mm (4.3612-4.3624 in.)	Blue
110.805-110.835 mm (4.3624-4.3636 in.)	Yellow

When replacing pistons, measure cylinder bore as described in General Gasoline Engine Service, Section 21-01. Install service piston matched to piston bore diameter above.

PISTON PIN

Engine	Length	Diameter		To Piston Pin Bore Clearance ①	To Connecting Rod Bushing Clearance
		Standard	.001 Oversize		
7.5L (460 CID) V-8	3.290-3.320	1.0398-1.0403	1.0410-1.0413	.0002-.0005	Interference Fit

① Selective Fit.

PISTON RINGS

Engine	Ring Width Compression		Side Clearance ①			Ring Gap		
	Top	Bottom	Compression		Oil	Compression (In Gauge)		Oil
			Top	Bottom		Top	Bottom	
7.5L (460 CID) V-8	.077-.078	.0770-.0780	.0025-.0045	.0025-.0045	Snug	.010-.020	.010-.020	.010-.035

① Service limit — .002 maximum increase in clearance.

OIL PUMP AND OIL CAPACITY

Engine	Relief Valve Spring Pressure Lbs. @ Specified Length	Driveshaft to Housing Clearance	Relief Valve to Housing Clearance	Rotor Assembly End Clearance	Outer Race to Housing Clearance	Engine Oil Capacity ①			Inner to Outer Rotor Tip Clearance
						U.S. Qts.	Imperial Qts.	Liters	
7.5L (460 CID) V-8	20.6-22.6 @ 2.49	.0015-.0030	.0015-.0030	.004 Maximum	.001-.013	5	4.2	4.7	.012

① Add 1 U.S. quart (or equivalent in Imperial quarts or liters) when replacing filter.

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TORQUE LIMITS — 7.5L (460 CID) EFI V-8 ENGINE

NOTE: All values are in N•m (ft-lbs) unless otherwise noted. Oil threads with engine oil unless the threads require oil or water-resistant sealer. The standard torque limits listed below are applicable for all functions not listed in the special torque chart.

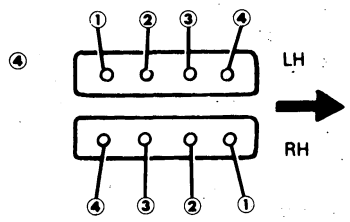
1/4-20	5/16-18	5/16-24	3/8-16	3/8-24	7/16-14	7/16-20	1/2-13	9/16-18
8-12 (6-9)	17-24 (12-18)	19-27 (14-20)	30-43 (22-32)	37-51 (27-38)	61-77 (45-57)	55-81 (40-60)	75-81 (55-60)	116-162 (85-120)

PIPE THREADS

1/8-27	1/4-18	3/8-18	1/2-14
7-11 (5-8)	17-24 (12-18)	30-44 (22-23)	34-47 (25-35)

Item	Torque N•m	Torque (ft-lbs)
Camshaft Sprocket — Gear to Camshaft	55-68	(40-50)
Camshaft Thrust Plate to Cylinder Block	8-12	(70-105 in-lb)
Connecting Rod Nut	55-61	(45-50)
Cylinder Front Cover — 5/16"	17-24	(15-21)
Cylinder Head Bolts	①	
Damper to Crankshaft	95-122	(70-90)
Distributor Clamp Down	24-33	(17-25)
EGR Valve to Upper Intake Manifold	8-11	(70-100 in-lb)
Flywheel to Crankshaft	103-115	(75-85)
Main Bearing Cap Bolts	129-142	(95-105)
Manifold to Cylinder Head — Intake	③	
Intake Manifold Vacuum Fittings ②	8-13	(6-10)
Manifold to Cylinder Head — Exhaust	30-60	(22-30)
Oil Filter Insert to Cylinder Block/Adaptor	61-203	(45-150)
Oil Filter Adaptor to Cylinder Block	54-88	(40-65)
Oil Filter to Adaptor or Cylinder Block	1/2 turn after gasket contacts sealing surface — oiled gasket	
Oil Inlet Tube to Pump	17-24	(12-18)
Oil Inlet Tube to Main Bearing Cap	30-43	(22-32)
Oil Pan Drain Plug	21-33	(15-25)
Oil Pan to Cylinder Block	1/4" 10-12 5/16" 11-15	(7-9) (8-11)
Oil Pump to Cylinder Block	30-43	(22-32)
Pully to Damper Bolt	48-67	(35-50)
Rocker Arm Stud/Bolt to Cylinder Head	25-33	(18-25)
Spark Plug to Cylinder Head	7-13	(5-10)
Valve Rocker Arm Cover	④	
Water Outlet Housing	16-24	(12-18)
Water Pump to Cylinder Block or Front Cover	20-28	(15-21)
Alternator Bracket to Water Pump — Bolt	46-54	(30-40)
Alternator Pivot Bolt	54-68	(40-50)
Alternator Adjusting Arm to Water Pump Bolt	46-54	(30-40)
Alternator Adjusting Arm to Alternator Bolt	46-54	(30-40)
Thermactor Pump Bracket to Cylinder Block	46-54	(30-40)
Thermactor Pump Pivot Bolt	46-54	(30-40)
Thermactor Pump to Pump Bracket	46-54	(30-40)
Thermactor Pump Pulley to Pump Hub	11-15	(100-130 in-lb)

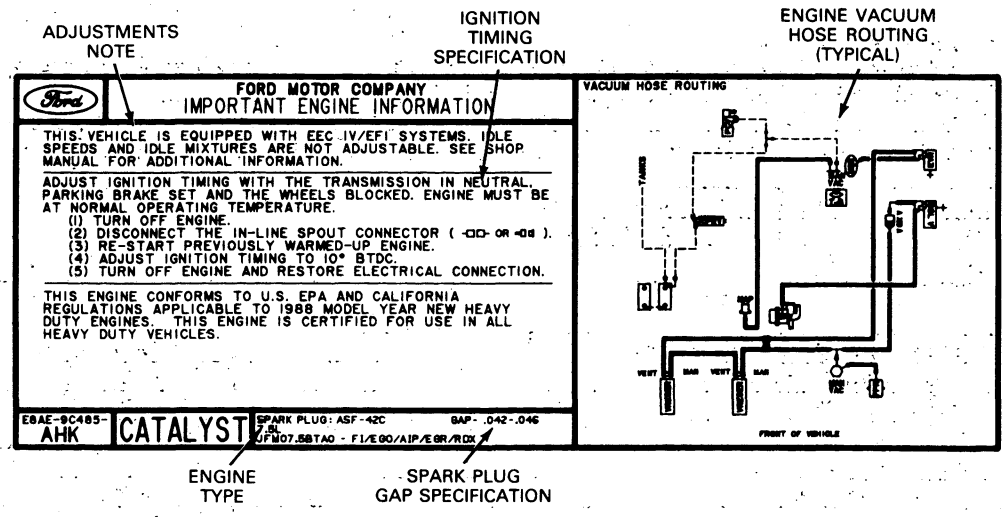
① Torque in steps: first to 95-108 N•m (70-80 ft-lbs), then to 136-149 N•m (100-110 ft-lbs), final to 177-189 N•m (130-140 ft-lbs).
② Index to correct position in tightening direction.
③ Torque in steps: first to 11-16 N•m (8-12 ft-lbs), then to 16-30 N•m (12-22 ft-lbs), final to 30-47 (22-35 ft-lbs).



Torque to 12-13 N•m (9-10 ft-lbs) in sequence as shown.

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SPECIAL SERVICE TOOLS

Tool Number	Description	Tool Number	Description
D79P-100-A	Impact Slide Hammer	D81L-6002-C	Piston Ring Compressor
T50T-100-A	Impact Slide Hammer	T65L-6250-A	Cam Bearing Set
T58L-101-B	Puller Attachment	T52L-6306-AEE	Crankshaft Damper & Sprocket Replacer
T59L-100-B	Impact Slide Hammer	T58P-6316-D	Crankshaft Damper Remover
T72J-1177	Bearing Housing Seal Replacer	TOOL-6331-E	Main Bearing Insert Tool
D78P-4201-B	Dial Indicator Mag. Base	T74P-6375-A	Flywheel Holding Tool
TOOL-4201-C	Dial Indicator With Bracketry	T70L-6500-A	Hydraulic Lifter Puller
T70P-6000	Engine Lifting Brackets	TOOL-6500-E	Hydraulic Tappet Leakdown Tester
T75T-6000-A	Engine Lifting Plate	T71P-6513-B	Tappet Bleed Down Wrench
T64L-6011-EA	Cylinder Ridge Reamer	TOOL-6513-DD	Valve/Clutch Spring Tester
T73L-6011-A	Cylinder Hone Set	TOOL-6565-AB	Cup Shaped Adapter
T68P-6019-A	Front Cover Aligner	T73L-6600-A	Pressure Gauge
T70P-6049-A	Valve Spring Compressor	D79P-6666-A	Spark Plug Boot Puller
T68P-6135-A	Piston Pin Remover/Replacer	T74P-6666-A	Spark Plug Wire Remover
T70P-6B070-A	Front Cover Seal Replacer	T74P-7137-A	Pilot Bearing Replacer
T70P-6B070-B	Front Cover Seal Remover	T73P-6571-A	Valve Seal Installer

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VEHICLE APPLICATION

F-250 Through F-350, F-Super Duty Chassis Cab, Stripped Chassis and E-250 Through E-350 Vehicles.

DESCRIPTION AND OPERATION

Engine Description

Refer to Figs. 1 through 5.

The 7.3L diesel engine is a four-cycle, naturally aspirated V-8 with overhead valves. It displaces 7.3 liters (444 cu. in.). The right bank of cylinders are numbered 1, 3, 5, 7, with number 1 being at the front. The firing order is 1-2-7-3-4-5-6-8.

The crankcase has been especially designed to withstand the loads of diesel operation. It utilizes four bolt main bearing caps to provide a strong support for the rotating parts. The crankcase also incorporates internal piston oil cooling jets which direct oil to the underside of the piston.

The crankshaft is a five main bearing unit with fore and aft thrust controlled at the center (NO. 3) bearing. Heavy-duty forged steel connecting rods attach to the crankshaft, two to each bearing throw. The piston pin is a free floating-type, permitting the pin to move or float freely in piston and rod. The piston pin is retained by snap-rings.

The camshaft is supported by five insert-type bearings pressed into the block. It is driven by a gear keyed to the crankshaft. Camshaft end thrust is controlled by a thrust flange located between the front camshaft journal and the thrust flange spacer.

The aluminum-alloy pistons are fitted with two compression rings and one oil ring.

The hydraulic valve tappets minimize engine noise and maintain zero valve lash (tappet clearance). This eliminates the need for periodic adjustment. The hydraulic valve tappets incorporate camshaft roller followers for improved camshaft wear characteristics.

The cylinder head assemblies feature pre-combustion chambers which provide superior combustion characteristics. The cylinder head assemblies are equipped with positive valve-rotating mechanisms located at the bottom of the intake and exhaust valve springs.

A solid-state glow plug system and block heater provide excellent cold weather start capability.

The engine is equipped with a combination fuel filter/fuel heater/water separator. The E-Series locates the fuel filter assembly on a bracket on the RH side of the engine. The F-Series locates the fuel filter assembly on the LH side of the engine by utilizing a filter base with an integral filter bracket.

The engine is equipped with a fully closed crankcase ventilation system. Crankcase vapors are directed to the intake manifold from a port in the Crankcase Depression Regulator (CDR) valve. It regulates crankcase pressure by providing a connection between the valley pan and the intake manifold. The crankcase depression regulator (CDR) valve is mounted on the intake manifold.

The rotary-type injection pump is located between the cylinder heads in a recess in the front of the engine. The engine governor is integral with the fuel injection pump. Operating principles and service instructions for the fuel system components are also provided in this Section.

The Fuel Injection Pump used on the 7.3 Liter Diesel Engine is located between the cylinder heads and the intake manifold in the vee at the front of the engine. It is an opposed plunger, inlet metered, positive displacement, distributor type pump.

Coolant Flow

Coolant flows from the radiator to the water pump, to the engine RH and LH banks (Fig. 6).

Circulation of the coolant is from the front to the rear of the crankcase. Coolant flows from crankcase to the cylinder head through positive cooling passages, and through one passage at the front and rear bulkhead of the cylinder head. Coolant flows between the pre-combustion chambers and valve seats and towards the front. Coolant exits the cylinder head into a common

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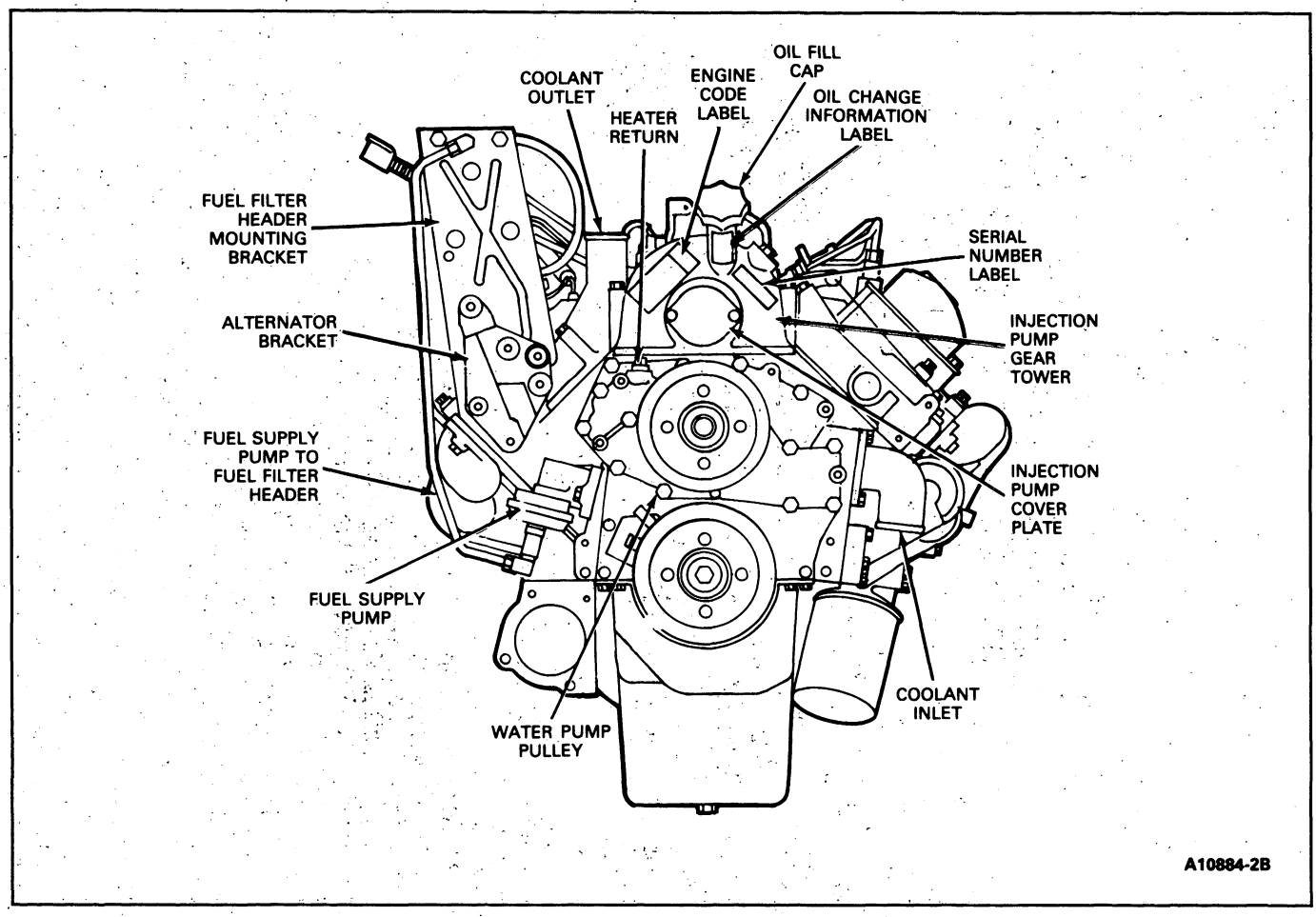


FIG. 1 7.3L Diesel—Front View—F-Series Shown, E-Series Similar

cavity which runs across the front of the crankcase. The common cavity routes coolant to the thermostat housing.

When the thermostat is closed, coolant bathes the thermostat and runs through the bypass orifice which is located below the thermostat. No coolant is allowed to enter the radiator.

When the coolant reaches 89°C (192°F) the thermostat begins to open. At the same time, the bottom of the thermostat moves closer to the bypass opening. The volume of coolant allowed to bypass is decreased, and coolant is permitted to circulate through the radiator. The thermostat is fully open at 100°C (212°F). Refer to Section 36-25, E-150—F-350 Heater System, for heater hose routing. Refer to Figs. 1 and 2 for coolant temperature sender, heater supply, heater return, and coolant drain locations.

Lubrication System

Lubrication oil is drawn out of the sump through the pick up screen and oil pick up tube to the oil pump (Fig. 7). Oil pump flow is 45.4 liters (12 gallons) per minute at rated speed and a pressure of 275-482 kPa (40-70 psi). From the oil pump, oil is passed through drilled passageways in the crankcase to the oil cooler header, then through the oil cooler. Oil flows around the outside of the heat exchanger tubes. (Coolant flows through the tubes). The oil passes from the oil cooler to the oil filter header. At the oil filter header, the oil meets the pressure regulating valve. The oil pressure regulator valve controls the volume and pressure of filtered oil supplied to the engine. The rear oil filter header also incorporates a bypass valve which opens if the oil filter becomes clogged. Five cross passages distribute oil to vertical passages which feed crankshaft main bearings, camshaft bearings and two tappet galleries. The piston cooling jets are fed from the same passage as the valve tappets. The connecting rod bearings are fed from the main bearings through drilled passages in the crankshaft. The timing gears are lubricated by oil splash. Oil passes through the hydraulic tappet rollers and up the hollow push rods to lubricate the rocker arm assemblies and valve stems.

Engine Components

Refer to Figs. 8, 8A, and 9 when performing procedures in this Section. Part descriptions and part numbers listed in the keys correspond with the Ford Master Parts Catalog.

Fuel Flow

Fuel from the tank is routed to the fuel supply pump which pumps fuel through a combination fuel filter, heater and water separator. The filter header contains a continuous vent (orifice bleed off system) which aids starting by eliminating the need to manually prime the fuel filter. A vacuum switch is incorporated into the fuel filter header which will activate an instrument panel lamp, indicating the need for filter replacement. The water separator portion of the filter assembly has a probe which activates an instrument panel lamp when

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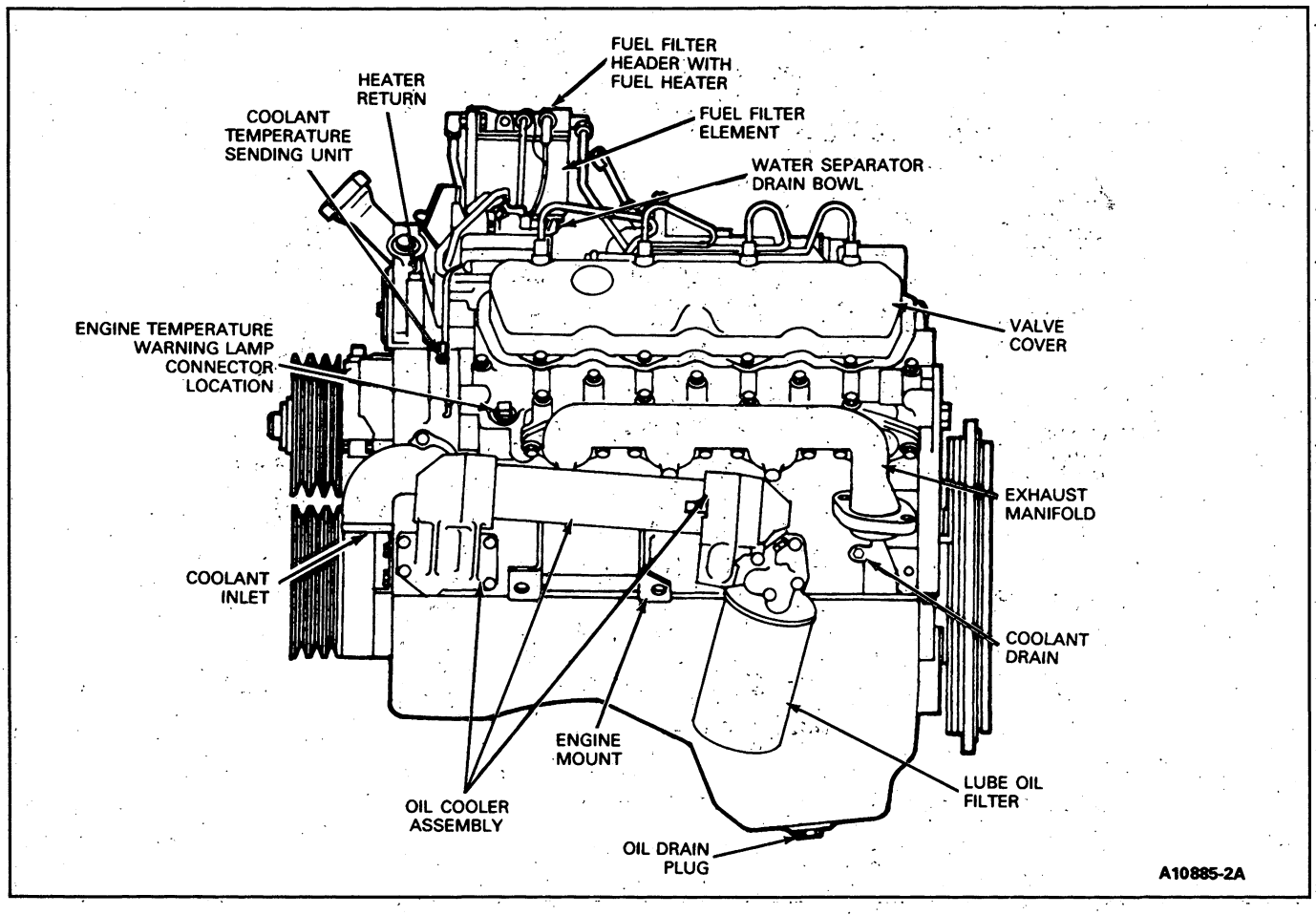


FIG. 2 7.3L Diesel—LH Side—F-Series Shown, E-Series Similar

the filter requires draining at the water and sediment drain (located on the bottom of the assembly.

WARNING: THE ENGINE FUEL SYSTEM WARRANTY IS NULL AND VOID IF ANY FUEL FILTER OTHER THAN AN APPROVED MOTORCRAFT® FILTER ELEMENT IS USED.

Fuel enters the inlet of the injection pump and is delivered under high pressure through injection nozzles into the engine cylinders for combustion. Each nozzle incorporates a fuel return fitting that returns excess fuel to the fuel tank. Excess fuel from the injection pump and each injection nozzle is collected in bleed off lines and returned to the fuel tank.

Injection nozzles are located on the inboard side of the cylinder head. This configuration has the following advantages:

- Injection nozzles operate in a cooler environment far removed from the exhaust manifold and exhaust ports.
- Injection lines do NOT interfere with engine accessories and provide better access to the engine for servicing.

Proper filtration of diesel fuel cannot be overemphasized. It is essential for long component life and reliability.

The Fuel Shut-Off solenoid controls the flow of fuel into the injection pump charging circuit (high pressure). With the ignition switch in START or RUN, the solenoid is energized and fuel is allowed to flow to the injection pump charging circuit. With the ignition switch OFF, fuel flow to the injection pump charging circuit stops.

Injection Pump

The diesel fuel injection pump accurately meters and delivers fuel to a nozzle in each cylinder at high pressure and at precisely timed intervals.

The injection pump is an opposed plunger, inlet metered, positive displacement, distributor type pump. The pump incorporates a single pumping chamber, an integral fuel transfer pump and governor, and an automatic injection advance mechanism. On-off control is provided by means of an electric solenoid located in the housing cover.

Operating principles of the pump can be understood by following the fuel circuit through a complete pump cycle (Figs. 10 and 11). Fuel flows into the injection pump inlet through an inlet filter screen (1). Fuel then flows to the vane-type fuel transfer pump (2). Excess fuel from the transfer pump is bypassed through the pressure regulator assembly (3) to the suction side.

Fuel under transfer pump pressure flows through the center of the transfer pump rotor, past the rotor retainers (4) into the hydraulic head. It then flows through a connecting passage (5) in the head to the automatic advance (6) and up through a radial passage to the metering valve (8). The position of the metering valve, controlled by the governor, regulates fuel flow into the radial charging passage (9) which incorporates the head charging ports. As the rotor revolves, the two

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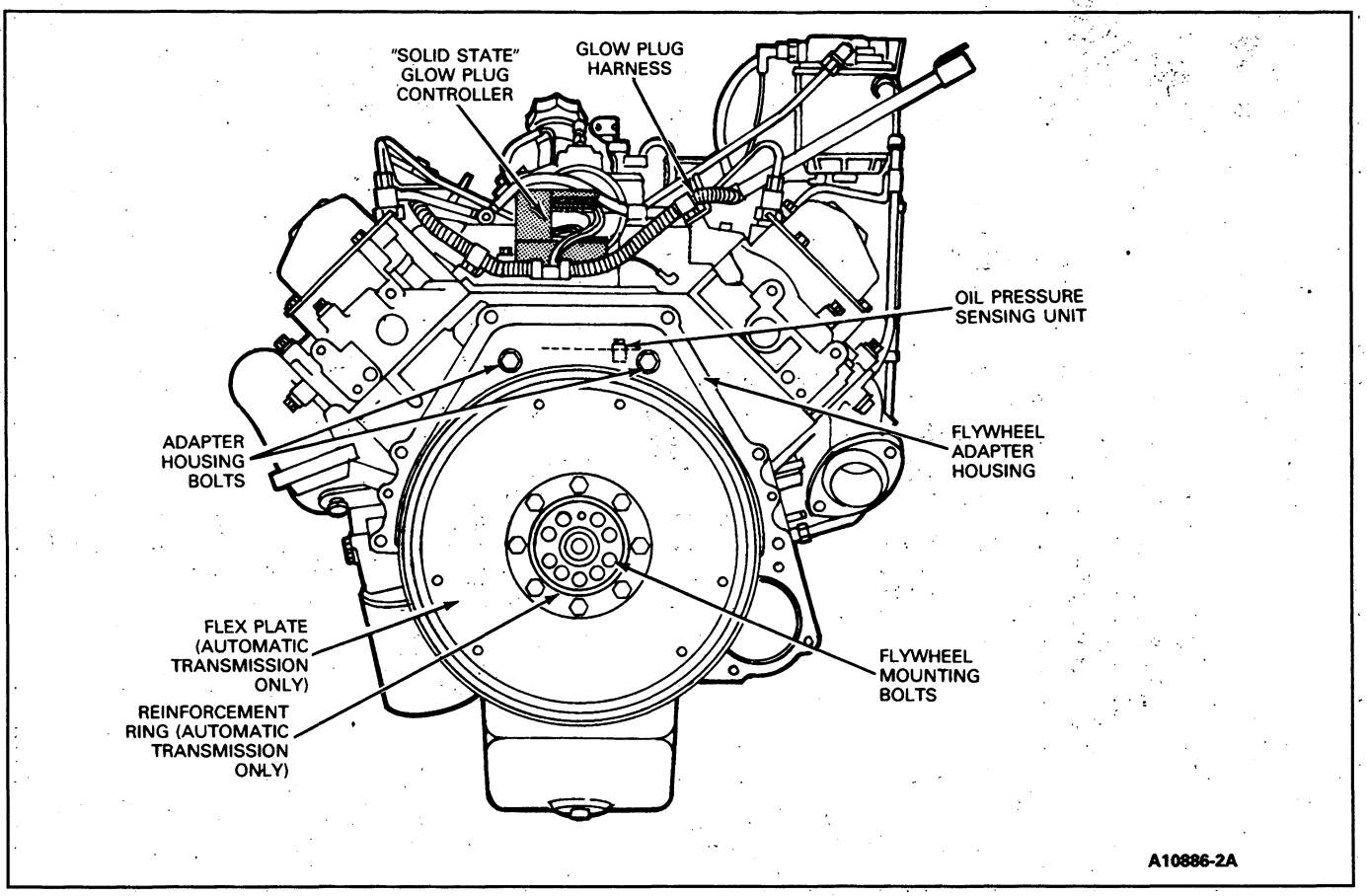


FIG. 3 7.3L Diesel-Rear View—F-Series

rotor inlet passages (10) align with the charging ports in the hydraulic head, allowing fuel to flow into the pumping chamber. With further rotation, the inlet passages move out of alignment and the discharge port of the rotor aligns with one of the head outlets. While the discharge port is opened, the rollers (11) contact the cam lobes forcing the plungers together. Fuel trapped between the plungers is then pressurized and delivered by the nozzle to the combustion chamber.

In addition, an air vent passage (12) in the hydraulic head connects the outlet side of the transfer pump with the pump housing. This allows air and some fuel to be bled back to the fuel tank through the return line. Fuel bypassed in this way fills the housing, lubricates the internal components, cools and carries off any small air bubbles.

Injection Nozzle Assemblies

Description

The injection nozzles are of the inwardly opening, differential, hydraulically operated, pintle-type. Their function is to direct a metered amount of fuel, under high pressure from the fuel injection pump, into the engine combustion chamber.

The injection nozzle assembly consists of two sub-assemblies; the nozzle and the nozzle holder. Fig. 12 illustrates the injection nozzle assembly.

Nozzle Holder

The nozzle holder retains the nozzle in its correct position in the cylinder head and provides channels for conducting diesel fuel to the nozzle.

Nozzle

The nozzle consists of two parts; nozzle body and nozzle valve. These parts are lapped to form an extremely close-fitting matched set.

The nozzle valve carries an extension at its lower end, called the pintle, which protrudes through the closely fitting hole in the bottom nozzle face. This construction requires the fuel to pass through an annular orifice.

Operation

Operation of the injection nozzle assembly is simple and positive. A metered quantity of fuel from the injection pump enters the nozzle holder through the inlet fitting. It then passes through ducts to the pressure chamber located just above the nozzle valve seat. At the instant the pressure of fuel acting on the differential area of the valve exceeds a predetermined spring-load, it lifts the valve from its seat and fuel flows from the nozzle until delivery from the injection pump ceases. Positive cut-off of fuel occurs as the valve is seated by the nozzle spring. A small amount of fuel leakage to the spring cavity is necessary for lubrication. This fuel leakage accumulates in the spring cavity and drains through to a leak-off outlet provided for this purpose.

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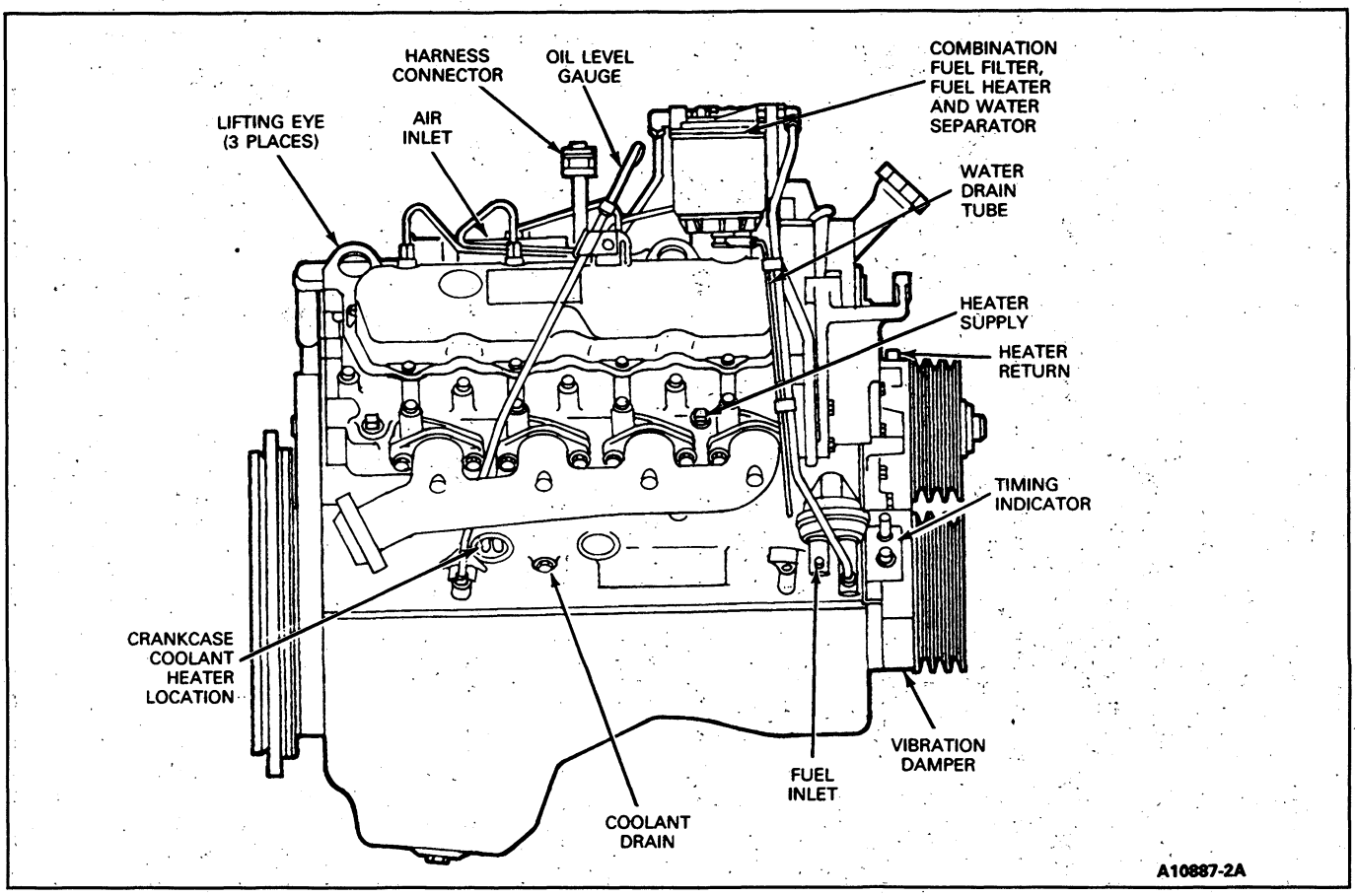


FIG. 4 7.3L Diesel—RH Side—F-Series

Nozzle opening pressure and spray pattern should be inspected every 96,500 km (60,000 mi.). Refer to Nozzle Testing in the Engine/Emissions Diagnosis Manual*.

Glow Plug Fast Start System

Refer to Figs. 13 and 14.

The 7.3L diesel engine utilizes a solid-state glow plug system to aid in the start of the engine. The system pre-heats air in the combustion chamber to aid ignition of the fuel.

The system consists of eight glow plugs (one for each cylinder), a solid-state glow plug controller/power relay assembly, two fusible links located between the Power relay and the glow plug harness (one for each bank of four glow plugs), WAIT TO START lamp and a wiring harness which incorporates eight fusible wires (one for each glow plug).

During initial start with cold engine, the glow plug system operates as follows:

When the ignition switch is turned to RUN, voltage is applied through the glow plug controller to the glow plug power relay. The contacts in the relay close, and voltage is applied to the WAIT TO START lamp and the glow plugs. The glow plugs are heated from zero to 15 seconds, depending upon engine temperature, then glow plug power relay voltage is cut off. This opens the relay contacts, turning off the GLOW PLUG indicator lamp and the glow plugs. The glow plugs are now warm enough for the engine to be started.

CAUTION: Hard starting will result if the ignition switch is left on for over two minutes without starting the engine. If the ignition switch is turned off, it can be turned on immediately and the glow plug heating cycle will start again.

An after-glow operation allows the glow plugs to cycle on and off after the WAIT TO START lamp has turned off. This helps to reduce white smoke during engine warmup. The lamp will **NOT** cycle on and off during this operation.

The solid-state system determines the glow plug temperature by electronically measuring the resistance of the glow plugs and maintains temperature regardless of ambient conditions. The system uses positive temperature coefficient (PTC) glow plugs with push-on bullet terminals. These are **NOT** interchangeable with previous model year glow plugs.

CAUTION: Never bypass the power relay of the glow plug system. Constant battery current (12 volts) to glow plugs will cause them to overheat and fail, possibly resulting in severe engine damage.

Dual Mass Flywheel (Manual Transmission Only)

The flywheel assembly used on the 7.3L-V-8 diesel engine is known as a dual mass flywheel (Fig. 18). The purpose of the dual mass flywheel is to provide one inertia mass connected directly to the engine crankshaft and a second inertia mass connected through the clutch system to the transmission. The dual mass flywheel

*Can be purchased as a separate item.

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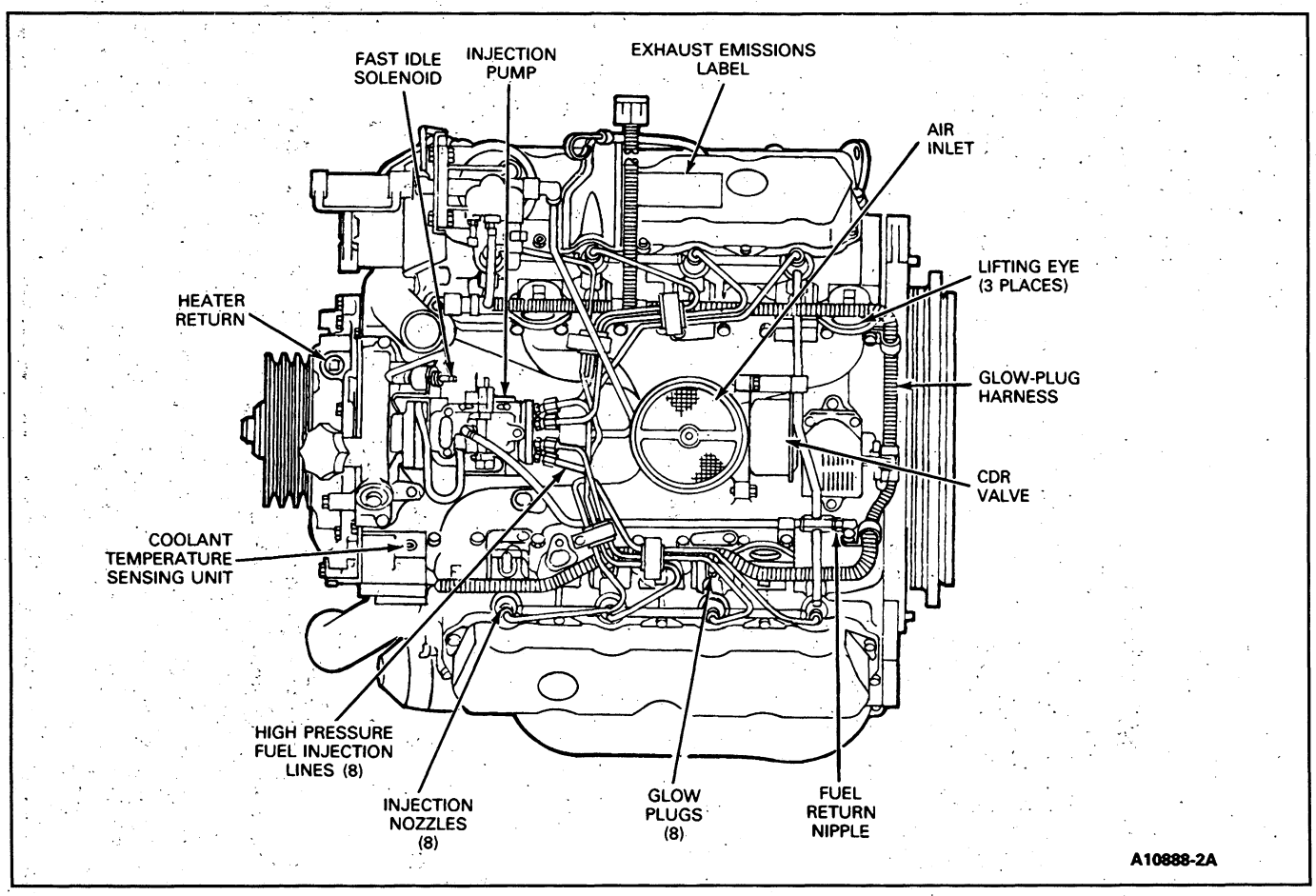


FIG. 5 7.3L Diesel—Top View—F-Series

provides the same functions as the conventional flywheel with mounting surfaces for the starter ring gear, clutch pilot bearing and clutch pressure plate and the friction surface for contact with the clutch disc.

The first inertia mass provides sustaining energy to maintain engine operation between the times that the cylinders fire and to maintain smooth power delivery.

The second inertia mass provides sustaining energy to the transmission for smooth, quiet transfer of power to the rear wheels.

Positioned between these two inertia masses is a series of springs and friction elements to provide smooth, quiet operation and a torque limitation function to protect the drivetrain from impact shock.

Another internal dual mass flywheel component is the central double row ball bearing used to mount the second inertia mass onto the first inertia mass. This bearing is designed for long life and requires no lubrication.

Vehicle and Engine Identification

Vehicle identification, the location of the vehicle rating and data plates and engine code information is fully covered in Section 20-00, Identification Codes. For specific and exact engine identification an engine code label is affixed to the gear tower. Refer to Figs. 15, 16 and 17 for examples of engine identification labeling.

Always refer to the engine code label when replacement parts are required or when checking engine calibrations. Some engine parts vary with engine application and vehicle type. The identification codes will ensure that the proper parts are obtained. The codes contain all pertinent information relating to dates, optional equipment and revisions. The Ford Master Parts Catalog contains a complete listing of the codes and their application. Additional identification information can be found in the permanent engine serial number (stamped on the front side of the crankcase the emission label (affixed to the value cover), or the engine serial sequence number label or oil change information label (near the engine code label on front of engine.

DIAGNOSIS AND TESTING

Diagnostic Procedures—Engine Components

Engine Oil Leaks

When diagnosing engine oil leaks, the source and location of the leak must be positively identified before any repairs are made. Prior to using this procedure, it is important to clean the cylinder block, cylinder head(s), rocker cover(s), oil pan and flywheel housing areas with a suitable solvent to remove all traces of oil.

CAUTION: Do not wash or steam clean the engine with engine running. Serious damage to the injection pump could result.

To perform oil leak diagnosis use Oil Leak Detector Rotunda Model 112-00001 (Fig. 19) or equivalent.

CAUTION: Do not use an air pressure leak test kit for diagnosing engine oil leaks. Loss of sealing may result at the valley pan seal.

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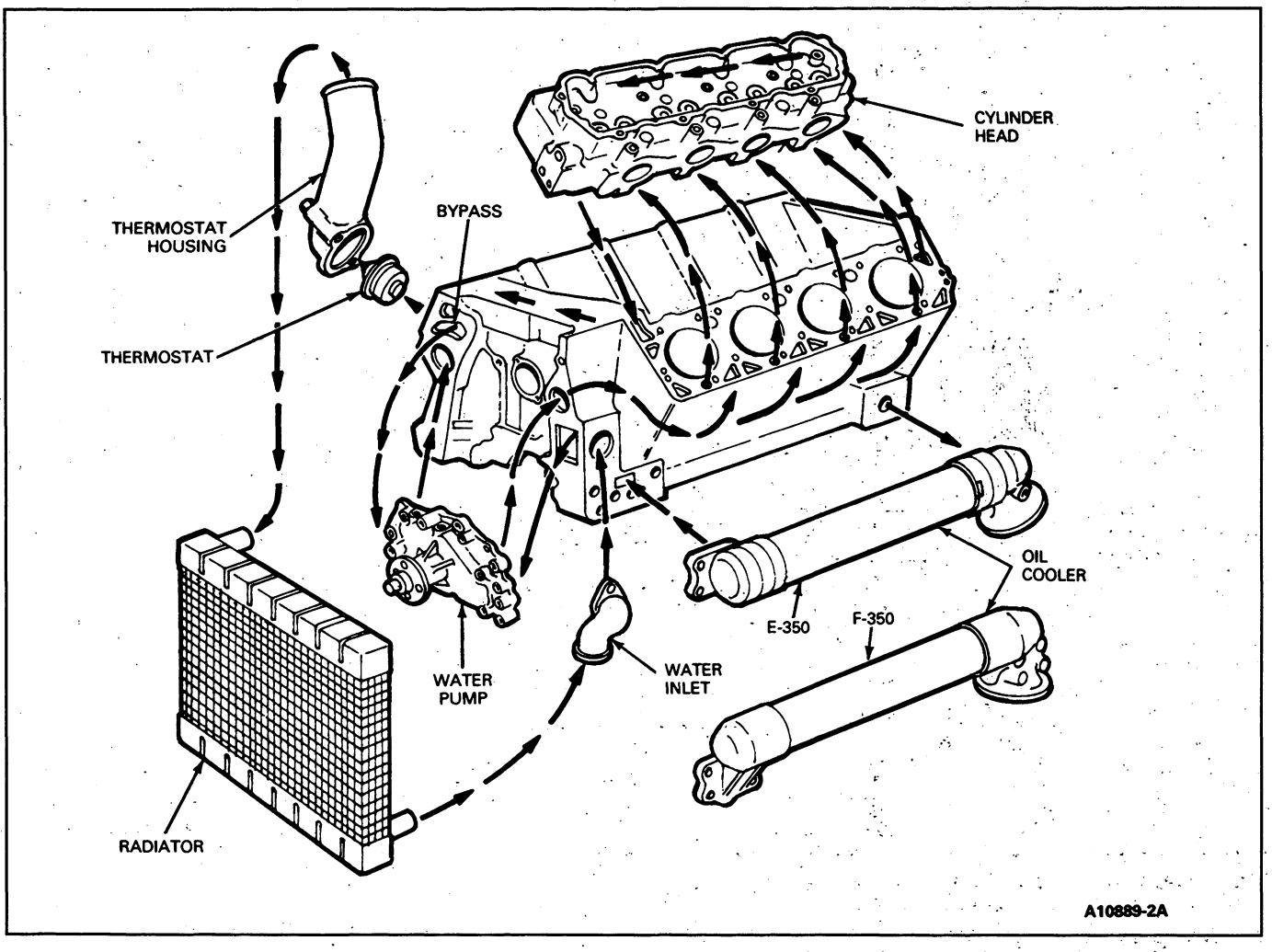


FIG. 6 Coolant Flow

To perform oil leak diagnosis use Oil Leak Detector Rotunda Model 112-00001 (Fig. 19), or equivalent.

1. Open two containers of dye by cutting off end of spout and empty entire contents of containers into crankcase.

   CAUTION: Dye may cause irritation. Avoid contact with skin or eyes. Wash thoroughly after handling.

2. Drive vehicle for five to ten miles at various road speeds.
3. Turn on spot lamp. (Lamp requires 3-5 minutes to warm up).
4. Open hood. Remove air cleaner and install intake manifold cover, using Intake Manifold Cover T83T-9424-A or equivalent, over intake manifold opening.
5. Inspect sealed and/or gasketed areas for leaks with the spot lamp. A leak will appear as a bright contrasting yellow-green fluorescence. Examine the following areas, as required:

Under Hood

a. Valve cover gaskets and around bolts.
b. Crankcase front cover gaskets.
c. Front and rear valley pan end seals.
d. Cylinder head gaskets.
e. Injection pump mounting adapter to crankcase.
f. Injection pump to adapter.
g. Front oil fill tube and oil fill cap.
h. Fuel supply pump and/or mounting gasket.
i. Oil pressure sending unit.
j. Cup plugs and/or pipe plugs at the end of oil passages.

Under Engine—With Vehicle on Hoist

a. The complete oil pan perimeter.
b. Crankcase front cover gaskets.
c. Front crankshaft seal.
d. Oil filter seal.
e. Oil cooler mounting gaskets and header O-rings.
f. Fuel supply pump and/or mounting gasket.
g. Oil level indicator (dipstick) tube connections.

With Transmission Removed

a. Flywheel mounting bolts.

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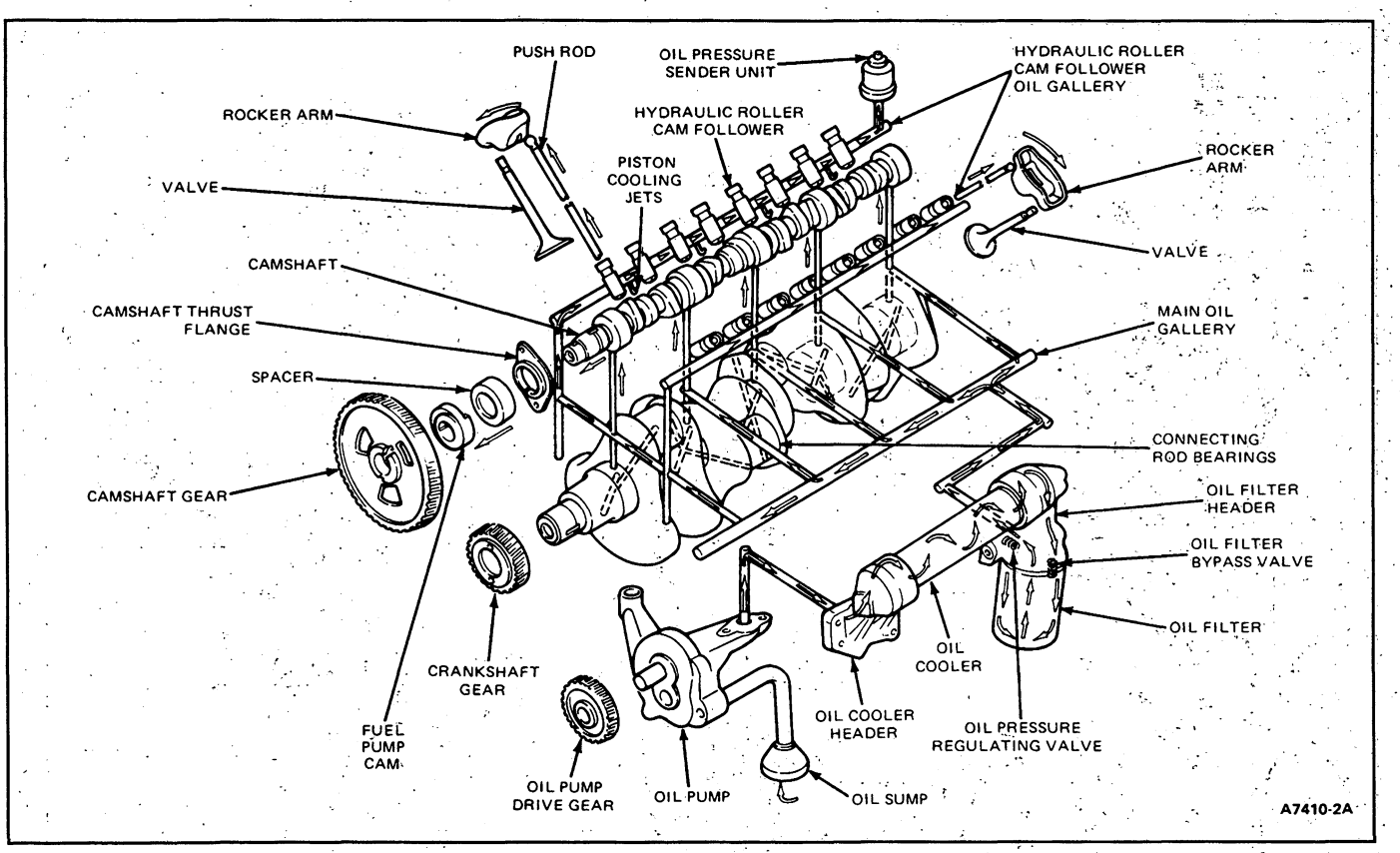


FIG. 7 Oil Flow

With Transmission and Flywheel Removed and Flywheel Mounting Bolt Holes Plugged

a. Rear crankshaft seal.

b. Rear cup plugs and/or pipe plugs.

c. Rear cover gasket.

d. Rear cover oil pan seal.

NOTE: Install specified sealant on flywheel bolts and install flywheel as outlined in this Section.

Oil Cooler Internal Leakage Test

When oil is found in the cooling system or coolant in the oil, the oil cooler assembly should be inspected for leakage.

Areas of possible leakage are:

- O-rings
- Oil Cooler Bundle (Tubes)
- Front Header
- Rear Header

Clean the cooling system if oil is found in the coolant. Refer to Section 27-02, Cooling System Service. If coolant is found in the oil, change engine oil and filter.

1. Remove oil cooler assembly from engine with filter installed as outlined in this Section.
2. Inspect the gaskets at the header flanges for leakage of coolant into the oil or oil into the coolant.
3. Using new header gaskets, assemble Rotunda Oil Cooler Internal Leakage Tester 014-00726 or equivalent, to the engine oil cooler by bolting the cover plate to the rear header, bolting the cover plate and tie bar assembly to the front header and bolting the tie bar to the rear header cover plate (Fig. 20).

   NOTE: Use original oil cooler tube and NOT test cooler tube included with Rotunda model 014-00726 Oil Cooler Internal Leakage Tester, or equivalent.

   NOTE: The inner O-ring (rust colored) must be installed in the header (not on the bundle) to avoid cutting the inner O-ring during assembly, (Fig. 21).
4. Pressurize coolant side of front header test plate (adapter A) at air supply fitting with 276.8 kPa (40 psi) air pressure.
5. Check for air leakage at the plastic tube or each header cover plate. If air leakage is not felt, place a cup of water up to the plastic tubes and look for bubbles. There should be no bubbles for a one-minute time period.

   NOTE: If no leakage is observed, the complete oil cooler assembly (headers, O-rings and cooler bundle (tube) **DOES NOT** have an internal leak. Install the oil cooler assembly to the engine as outlined in this Section. Continue engine diagnostic procedures to identify the source of the leak.

   NOTE: Steps 3 through 5 may also be used as a functional test of a newly overhauled oil cooler assembly.
6. If air leakage is observed, unbolt the test kit tie bar and remove the front and rear headers from the cooler bundle (with cover plates attached to headers). Replace the four cooler bundle O-rings.

   NOTE: A rust colored O-ring must be installed in each header, not on the bundle tube, to avoid

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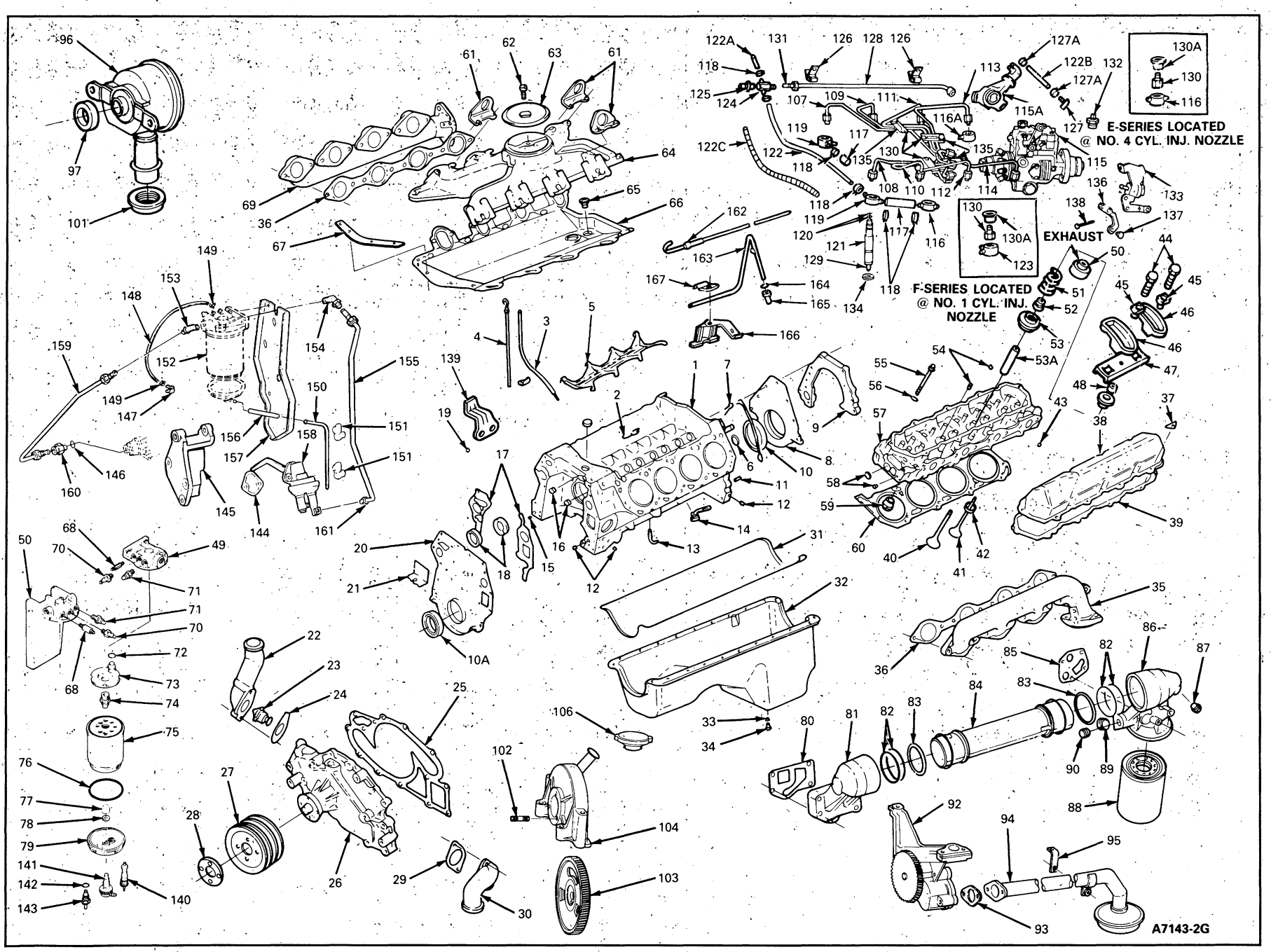


FIG. 8 7.3L Diesel—Exploded External View

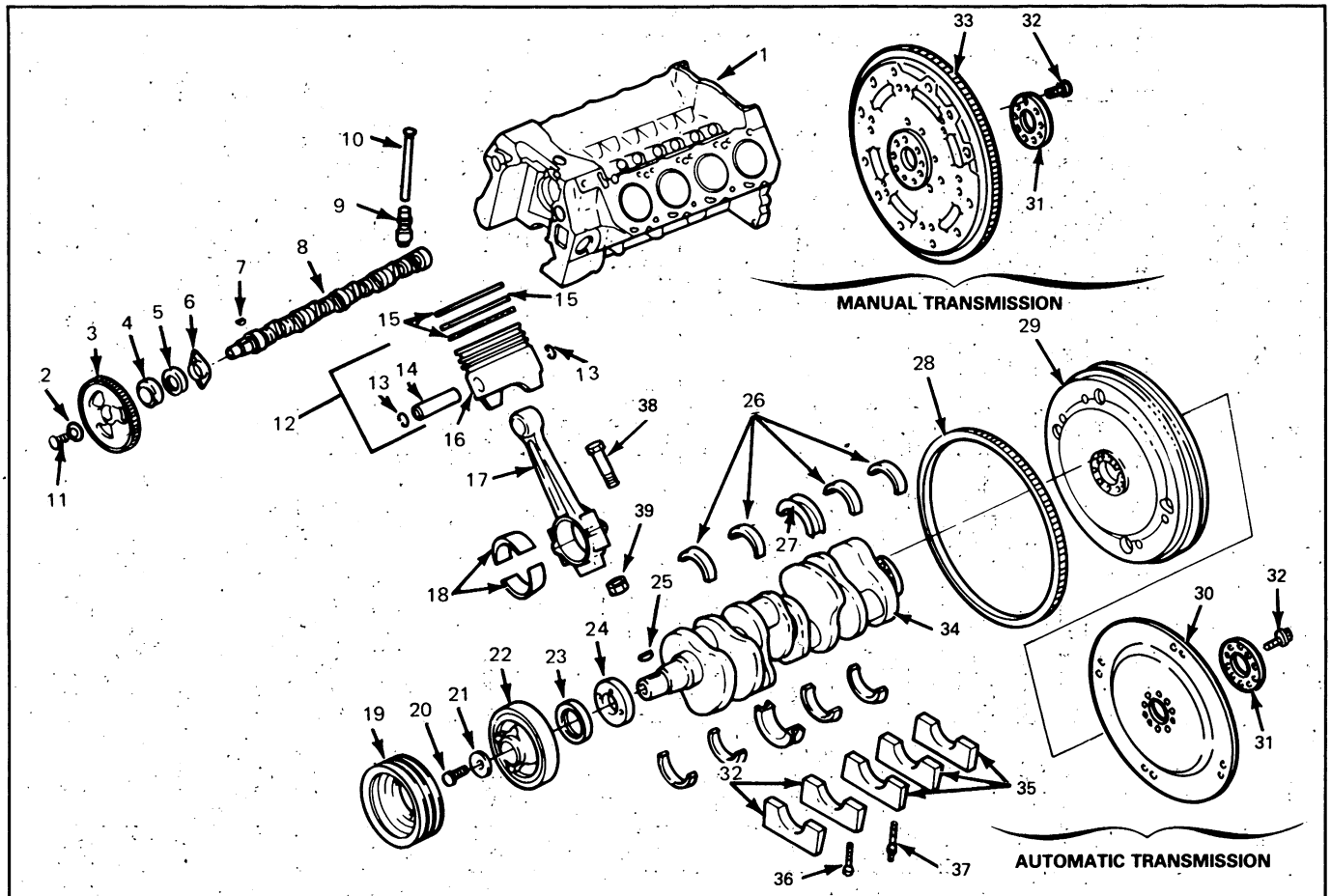
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REF. NO.	BASIC PART NO.	DESCRIPTION	REF. NO.	BASIC PART NO.	DESCRIPTION	REF. NO.	BASIC PART NO.	DESCRIPTION	REF. NO.	BASIC PART NO.	DESCRIPTION
1	6009H	Cylinder Block Assy.	45	—	Post, Valve Lever	89		Plug, 1/2 Inch	132	9E939	Temperature Switch
2	6C329A	Guide, Tappet	46	—	Lever, Valve	90		Plug, 1/2 Inch	133	12B526	Bracket and Solenoid-Fast Idle
3	6754	Tube Assembly, Oil Level Gauge (F-Series)	47	—	Retainer, Valve Lever Post	92	6600	Oil Pump Assy.	134	—	Gasket Nozzle (8)
			48	—	Lock, Valve Spring Retainer	93	6626	Gasket, Oil Pick-Up	135	9N653	Clamp
4	6750	Oil Level Gauge (F-Series)	49	6514A	Retainer, Valve Spring (36)	94	6622	Pick-Up Tube	136	9F541	Kickdown Lever (Auto. Trans.)
5	6C330A	Retainer, Tappet Guide	50	—	Shield, Oil (Exhaust)	95	6A661	Bracket, Oil Pick-Up	137	9D927	Screw, Kickdown Lever
6	6026A	Plug, Engine (1-1/2" O.D.)	51	6513B	Spring, Valve, with Damper (16)	96	6A665	CDR Valve	138	9F539	Adjusting Screw (Kickdown Lever)
7	6D083A	Gasket, Rear Cover	52	6571A	Seal, Valve Stem-Intake (8)	97	6A892	Seal Ring, CDR Valve	139	6786	Bracket, Oil Level Tube Support (F-Series)
8	6L080A	Cover Assembly, Engine, Rear	53	6K533A	Rotator, Assembly Valve (16)	100	6758	Crankcase Vent Tube			
9	6A369A	Adapter, Flywheel to Transmission	53A	—	Guide, Valve (Service)	101	6769	Grommet, Valley Cover	140		Vent/Valve Assembly
10	6701A	Rear Oil Seal, Crankshaft	54		Plug, 1/2 inch NPTF (4)	102	9F733	Mounting Stud, Injection Pump	141		Manual Drain Valve
10A	—	Front Oil Seal	55	6065A	Bolt Cylinder Head (34)	103	9A546	Drive Gear, Injection Pump	142		Water Sensor O-Ring
11	6B041B	Dowel Pin, Fly Wheel Adapter	56	6L015A	Washer, Cylinder Head Bolt (34)	104	9C516	Adapter Housing, Injection Pump	143		Water Sensor Probe
12	87614S	Pipe Plug, 1/8 NPTF	57	6049A	Cylinder Head Assembly (2)	106	6766	Cap, Oil Filler	144		Fuel Pump Supply Gasket
13	6C327A	Piston Cooling Jet	58	6026B	Plug, 1/4 Inch	107	9A555H	Pipe w/Nuts Pump to Cyl. 8	145		Alternator Bracket
14	6A051A	Heater Assembly, Block	59	6057A	Insert, Combustion Chamber (8)	108	9A555G	Pipe w/Nuts Pump to Cyl. 7	146		Sealing O-Ring
15	6B041A	Dowel Pin, Front Cover Plate	60	6051B	Gasket, Cylinder Head (2)	109	9A555F	Pipe w/Nuts Pump to Cyl. 6	147		Fuel Return Tee (At Nozzle)
16	6026E	Cup Plug	61		Eye, Lifting (3)	110	9A555E	Pipe w/Nuts Pump to Cyl. 5	148		Hose, 3/16" ID x 10" Long
17	6020A	Gasket, Front Cover Plate	62	9C629A	Insert, Bolt Thread-Air Cleaner Stud	111	9A555D	Pipe w/Nuts Pump to Cyl. 4	149		Hose Clip
18	6A251A	Bearing Kit, Camshaft				112	9A555C	Pipe w/Nuts Pump to Cyl. 3	150		Water Drain Tube
19	6A628A	Ball, Oil Indicator Hole 11/32"	63	9F460A	Screen, Intake Manifold	113	9A555B	Pipe w/Nuts Pump to Cyl. 2	151		Drain Tube Clamp (Z)
20	6B070A	Plate, Front Cover	64	9424B	Manifold, Intake	114	9A555A	Pipe w/Nuts Pump to Cyl. 1	152		Fuel Filter/Water Separator Element
21		Indicator, Timing (Part of Front Cover)	65	9A450A	Drain Plug, Valley Pan	115	9A543	Injection Pump	153		Elbow
			66	9439B	Gasket and Valley Pan	115A	—	Valve, Vacuum Modulator (Auto. Trans.)	154		Elbow, Fuel Supply Pump to Filter Header
22	8592G	Connection, Water Outlet	67	9B470A	Strap, Valley Pan						
23	8575	Thermostat	68		Fuel Priming Valve and Cap	116	—	Fuel Return Tee	155		Fuel Pump to Fuel Header Tube (With Two Nuts and Two Sleeves)
24	8255A	Gasket, Water Outlet	69	9430A	Manifold, Exhaust, Right	116A	—	Elbow, Fuel Return (F-Series)			
25	8507A	Gasket, Water Pump	70		Continuous Vent with Check Valve	117	—	Hose	156		Hose, 3/16" x 2-5/16" Long
26	8501D	Water Pump	71		Vacuum Switch (Fuel Filter Element Replacement Indicator)	118	9B255	Clip	157		Fuel Filter Header Mounting Bracket
27	8509D	Pulley, Water Pump				119	9A564	Fuel Return Tee	158		Fuel Supply Pump
28	8546A	Spacer, Fan	72		Fuel Heater O-Ring	120	87032-S92	O-Rings	159		Filter to Injection Pump Tube (With Two Nuts and Two Sleeves)
29	8255A	Gasket, Water Inlet	73		Fuel Heater	121	9E527	Injection Nozzle Holder			
30	8592D	Connection, Water Inlet	74		Threaded Insert	122	—	Fuel Return Hose	160		Connector Fitting
31	D6AZ-19562-A	RTV Sealant	75		Fuel Filter Element	122A	—	Hose	161		Inverted Flare Tube Nut
32	6675C	Oil Pan	76		Drain Bowl O-Ring	122B	—	Hose, Pump to Fuel Return Tube	162		Oil Level Gauge — E-Series
33	6734A	Gasket, Oil Pan Drain	77		Drain Valve Stem Cap	122C	—	Guard, Rear Fuel Return Hose	163		Tube Assembly, Oil Level Gauge — E-Series
34	6730A	Plug, Oil Pan Drain	78		Drain Valve Seal	123	—	Fuel Return Tee (E-Series)			
35	9431B	Manifold, Exhaust, Left	79		Water Separator Drain Bowl	124	9F734	Fuel Return Junction Fitting	164		O-Ring, Oil Level Gauge — E-Series
36	9448A	Gasket Exhaust Manifold	80	6A636A	Gasket, Oil Cooler, Front Header	125	—	Nipple, Fuel Return	165		Oil Level Gauge Tube, Lower — E-Series
37	6A532A	Washer, Valve Cover	81		Header, Oil Cooler, Front	126	9N659	Clamp			
38	6582C	Valve Cover	82	6K649A	O-Ring, Oil Cooler (2)	127	9F736	Elbow	166		Bracket, Oil Level Gauge Tube — E-Series
39	6584A	Gasket, Valve Cover	83	6C610A	O-Ring, Oil Cooler (2)	127A	—	Clip			
40	6507D	Valve, Intake (8)	84	6A642A	Cooler, Oil	128	9D308	Tube	167		Retainer, Oil Level Gauge Tube — E-Series
41	6505	Valve, Exhaust	85	6A636B	Gasket, Oil Cooler, Rear Header	129	—	Nozzle Tip			
42	6057B	Insert, Exhaust Valve Seat	86	6881B	Header, Oil Cooler, Rear	130	—	Sensor, Fuel Line Pressure			
43	6026F	Plug, Ball Type 13/32" (8)	87	6K862A	Plug, 1/4-Inch	130A	—	Cover			
44	—	Bolt, Valve Lever and Washer	88	6731A	Oil Filter	131	9C387	Sleeve Seal, Fuel Return (2)			

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FIG. 8A 7.3L Diesel—Exploded External View-Key

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REF. NO.	BASIC PART NO.	DESCRIPTION	REF. NO.	BASIC PART NO.	DESCRIPTION
1	6009H	Cylinder Block Assembly	21	6278B	Washer, Crankshaft
2	6278A	Washer, Camshaft	22	6379A	Damper, Crankshaft
3	6256A	Gear, Camshaft	23	6700A	Seal, Crankshaft Front Oil
4	6287A	Eccentric, Fuel Pump	24	6306A	Gear, Crankshaft Drive
5	6265A	Spacer, Camshaft Gear	25	6B316A	Key, Crankshaft Alignment
6	6269A	Camshaft Thrust Plate	26	6333A	Bearng, Crankshaft
7	6L269A	Key, Camshaft Alignment	27	6337A	Bearing, Crankshaft Thrust
8	6250B	Camshaft	28	6384A	Ring Gear, Flywheel
9	6500A	Roller Tappet	29	—	Flywheel — Automatic Transmission
10	6565A	Push Rod	30	—	Flex Plate — Automatic Transmission
11	6K252A	Bolt, Camshaft Drive Gear	31	—	Reinforcement Ring
12	6108G	Set, Piston, Pin	32	6379A	Bolt, Flywheel to Crankshaft
13	6140A	Retainer, Piston Pin	33	6477	Flywheel Dual Mass — Manual Transmission
14	6135B	Piston Pin	34	6303A	Crankshaft (with Bearings)
15	6148D	Piston Rings	35		Bearing Cap (Part of Cyl. Block Assy.)
16		Piston (Not Available Separately)	36	6345A	Bolt, Bearing Cap
17	6200A	Connecting Rod	37	6345B	Stud, Bearing Cap
18	6211A	Bearing Kit, Connecting Rod	38	6214A	Bolt, Connecting Rod
19	6A312A	Pulley, Crankshaft	39	6212A	Nut, Connecting Rod
20		Bolt, Hex Head			

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FIG. 9 7.3L Diesel—Exploded Internal View

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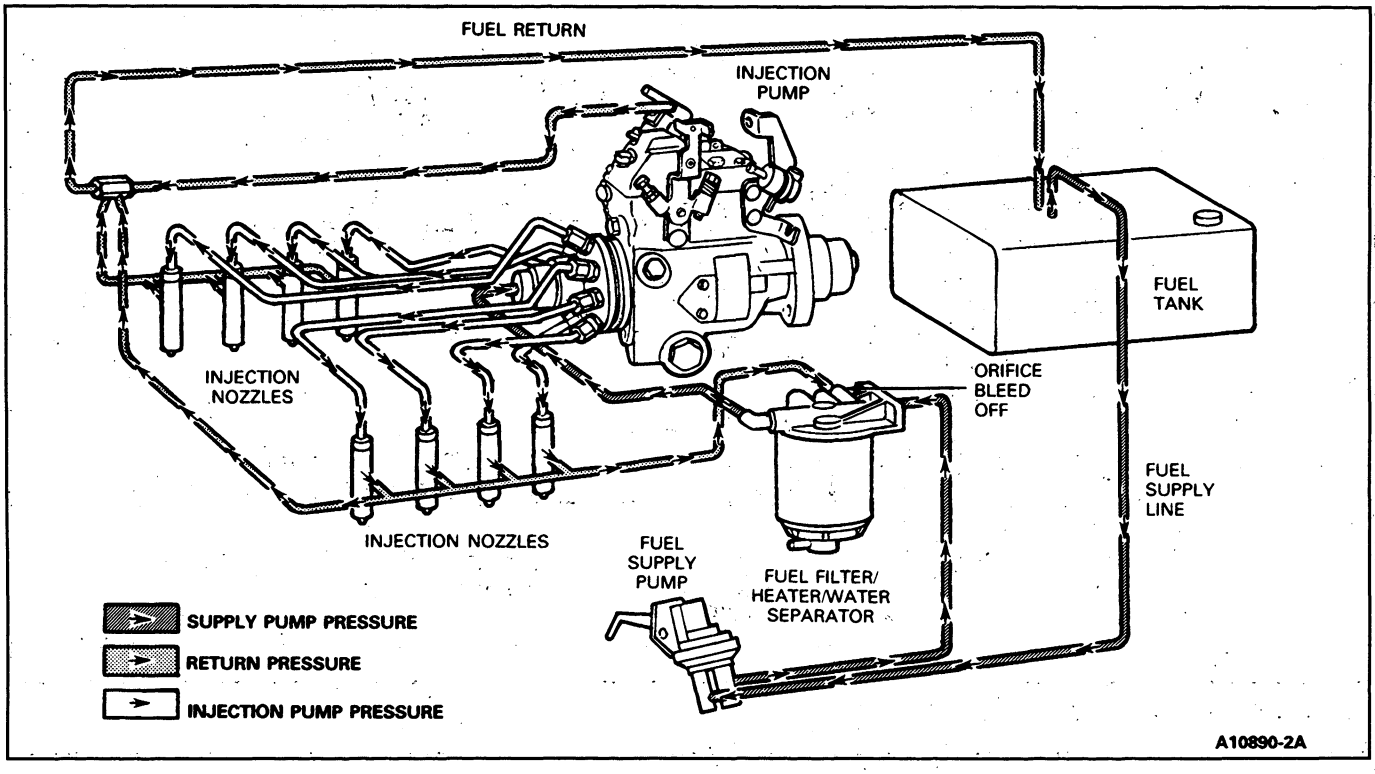


FIG. 10 Fuel Flow

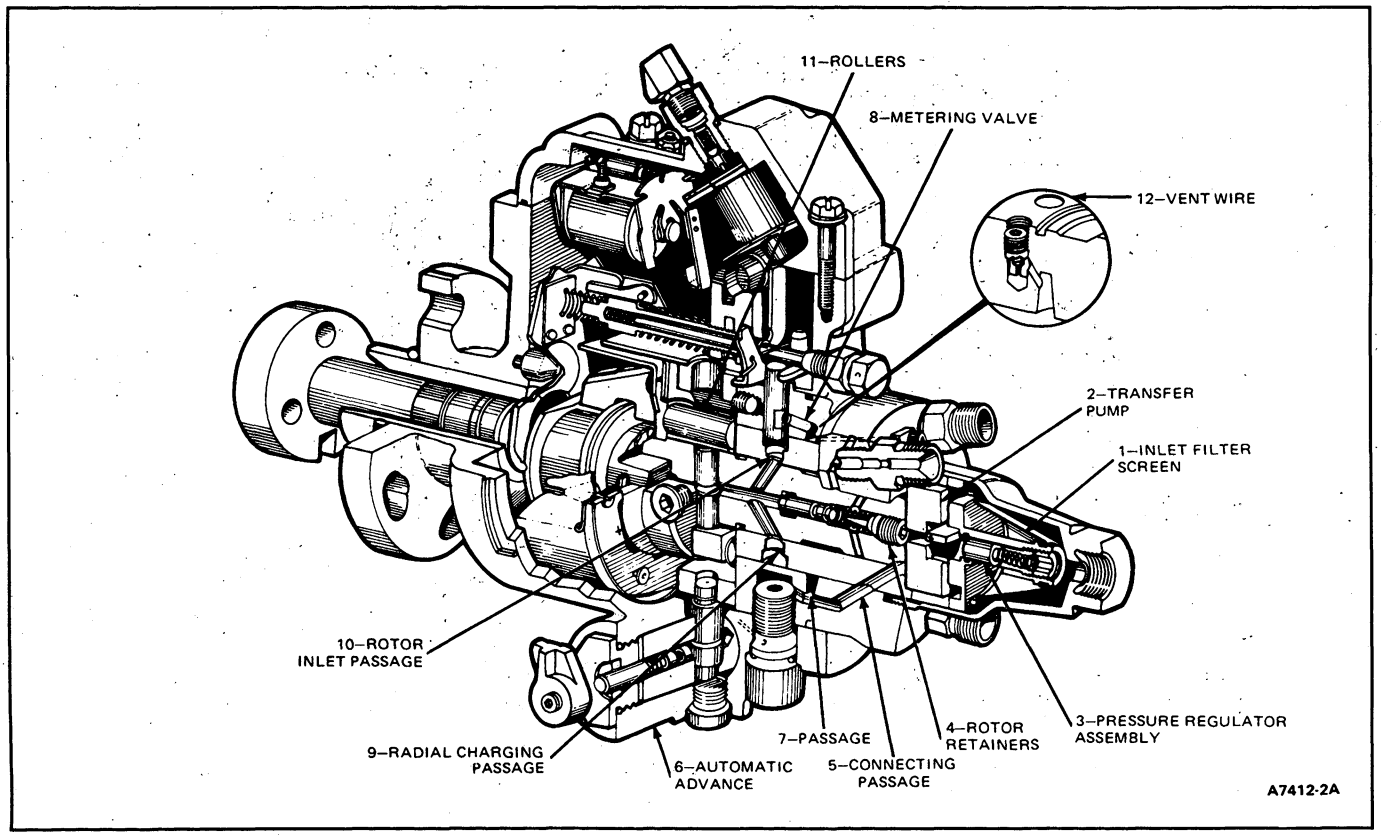


FIG. 11 Injection Pump Internal View

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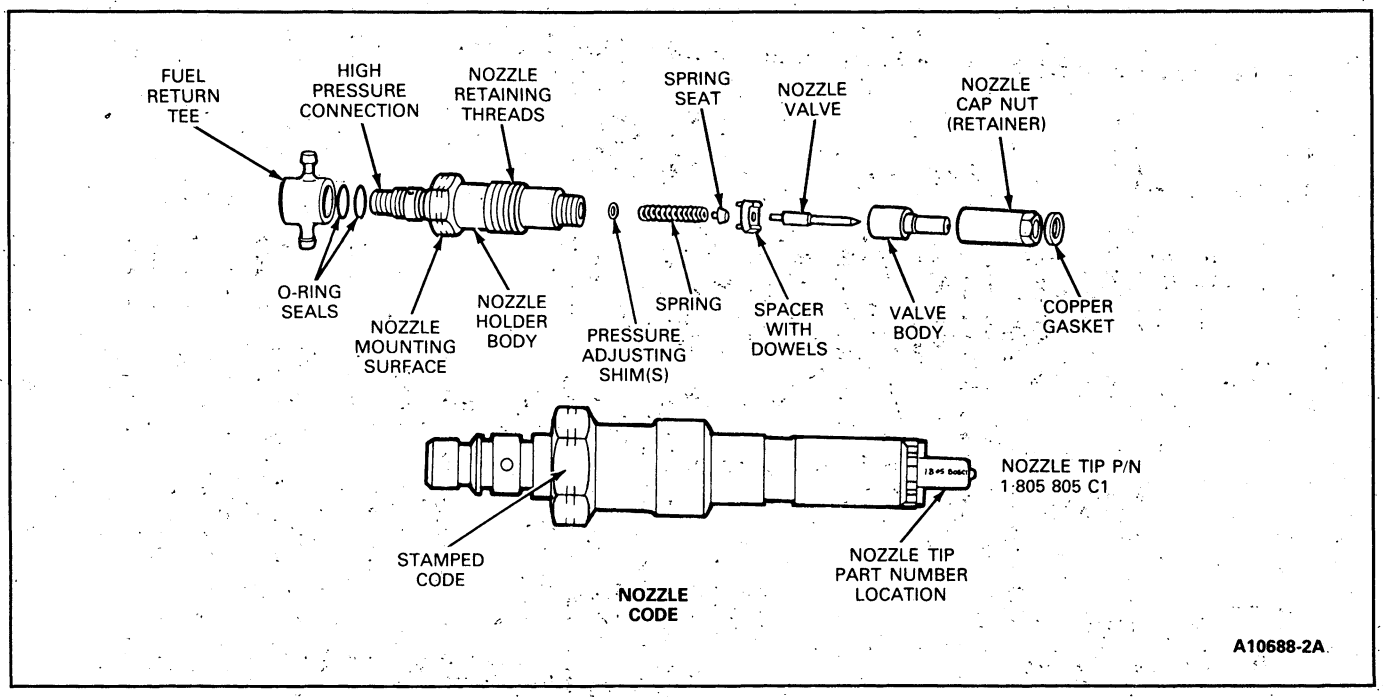


FIG. 12 Injection Nozzle Assembly

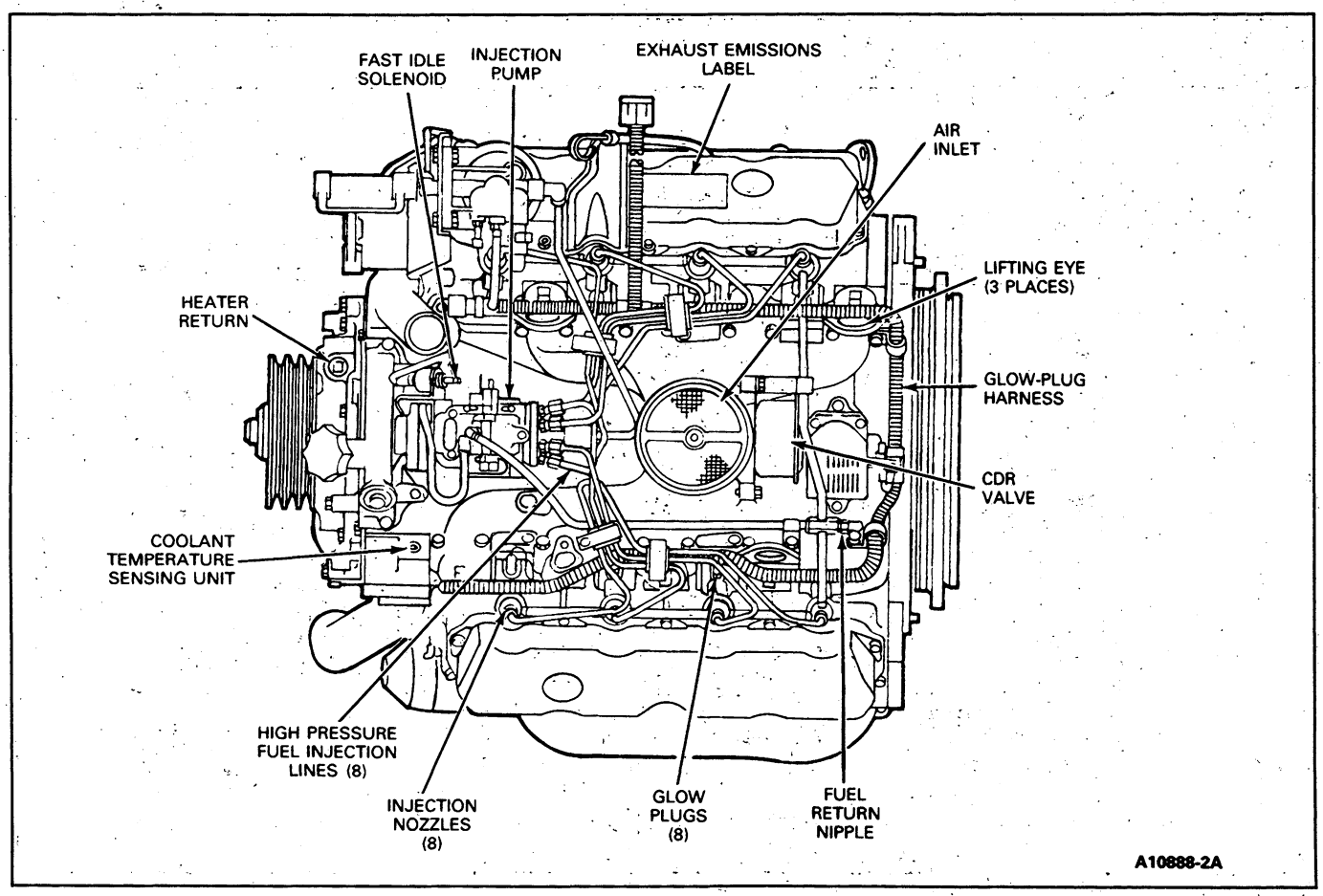


FIG. 13 Glow Plug Engine Harness

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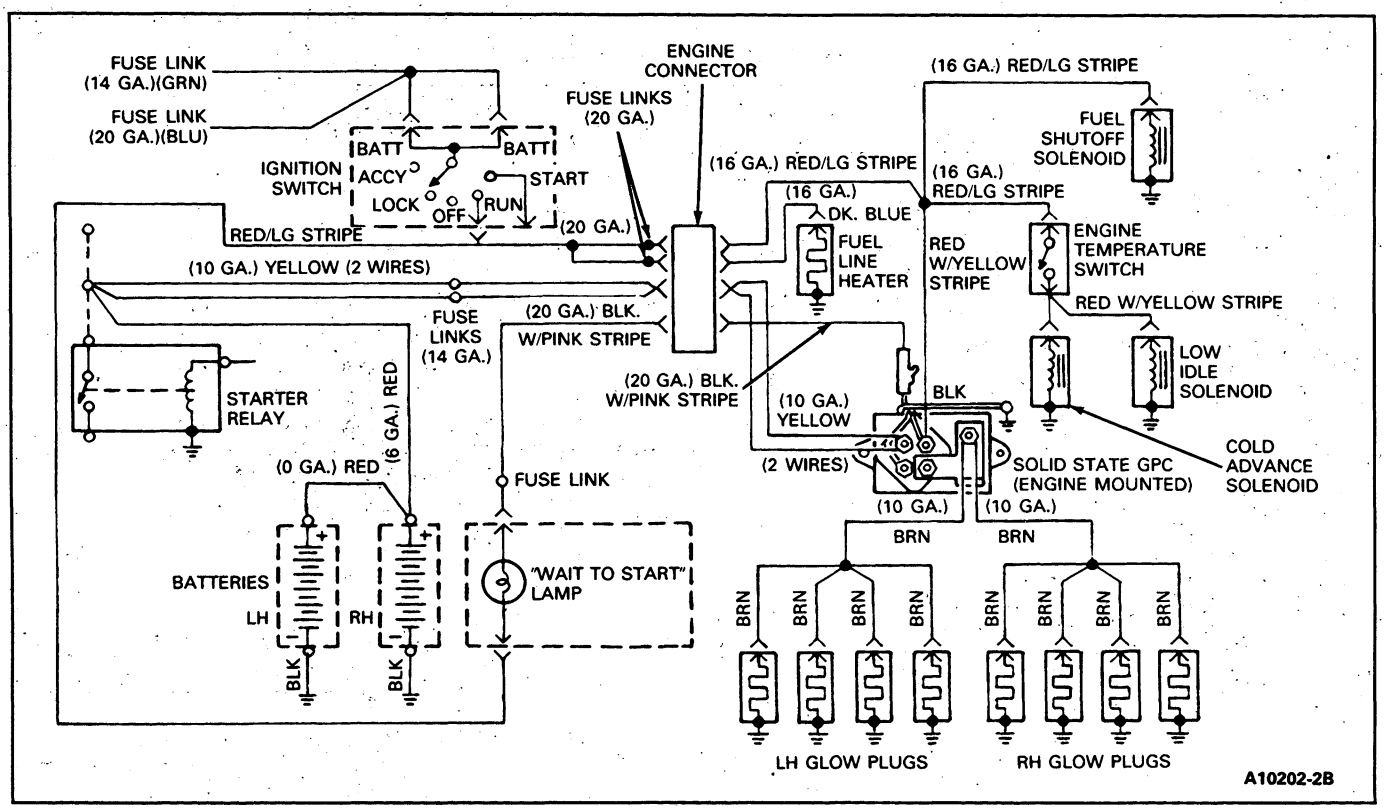


FIG. 14 Glow Plug Schematic

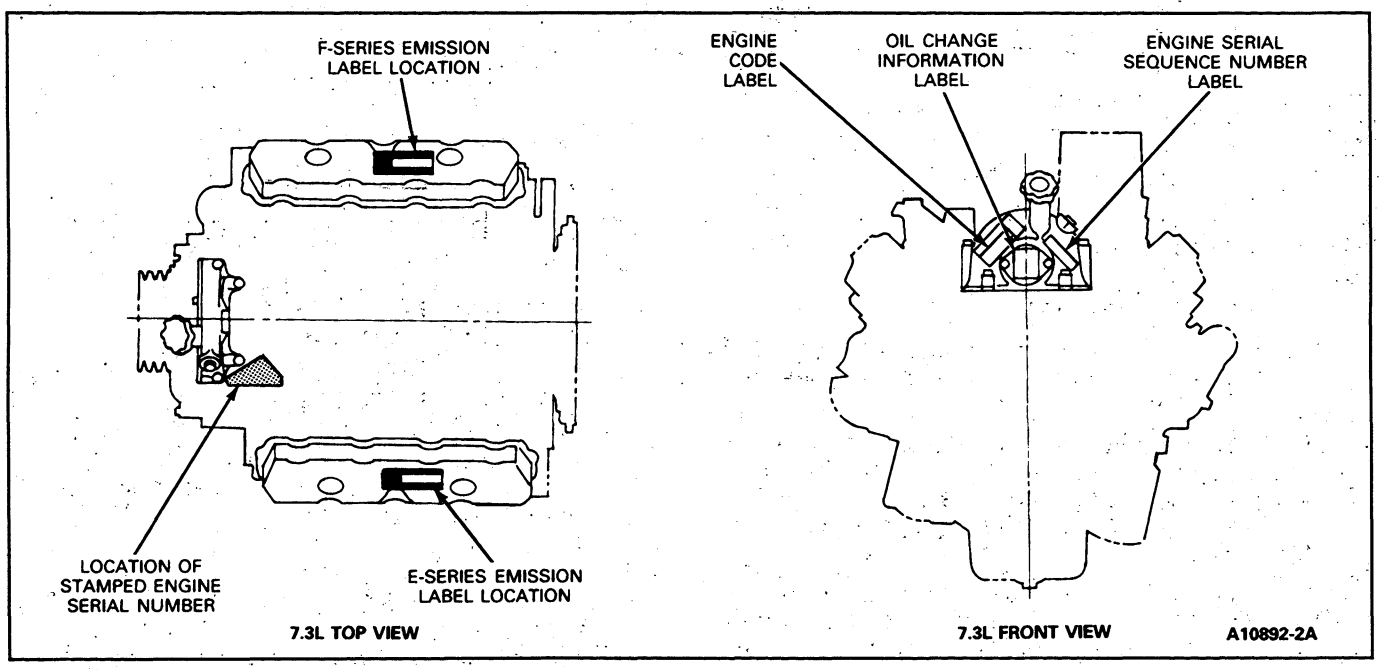


FIG. 15 Engine Identification

cutting the O-rings during assembly. Assemble the headers on the cooler bundle tube.

7. Bolt the test kit tie bar to the rear header cover plate. Repeat Steps 4 and 5 with the cooler assembly submerged in water. If leakage persists, isolate the worn or damaged component in the oil cooler assembly, as follows:

   A) For a leaking oil cooler still covered by warranty (3 yrs. or 50,000 miles) go to Step 8.

   B) For a leaking oil cooler not covered by warranty go to Step 10.

8. For a leaking oil cooler covered by warranty, replace and retest the following oil cooler components in the following sequence until no leakage is observed:

   1. Front header
   2. Rear header

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ENGINE SERIAL NUMBER CHART

ENGINE DISPLACEMENT	VARIATION CODE	COUNTRY OF ORIGIN	SERIAL SEQUENCE NUMBER
7.3	DU2	U	500001*

7.3 = Engine Displacement in Liters
D = Naturally Aspirated
U2 = OEM Application
U = Country of Origin - U.S.A.
000501 = Starting Sequence Number
* = Used to Prevent Tampering

ENGINE CODE LABEL IDENTIFICATION CHART

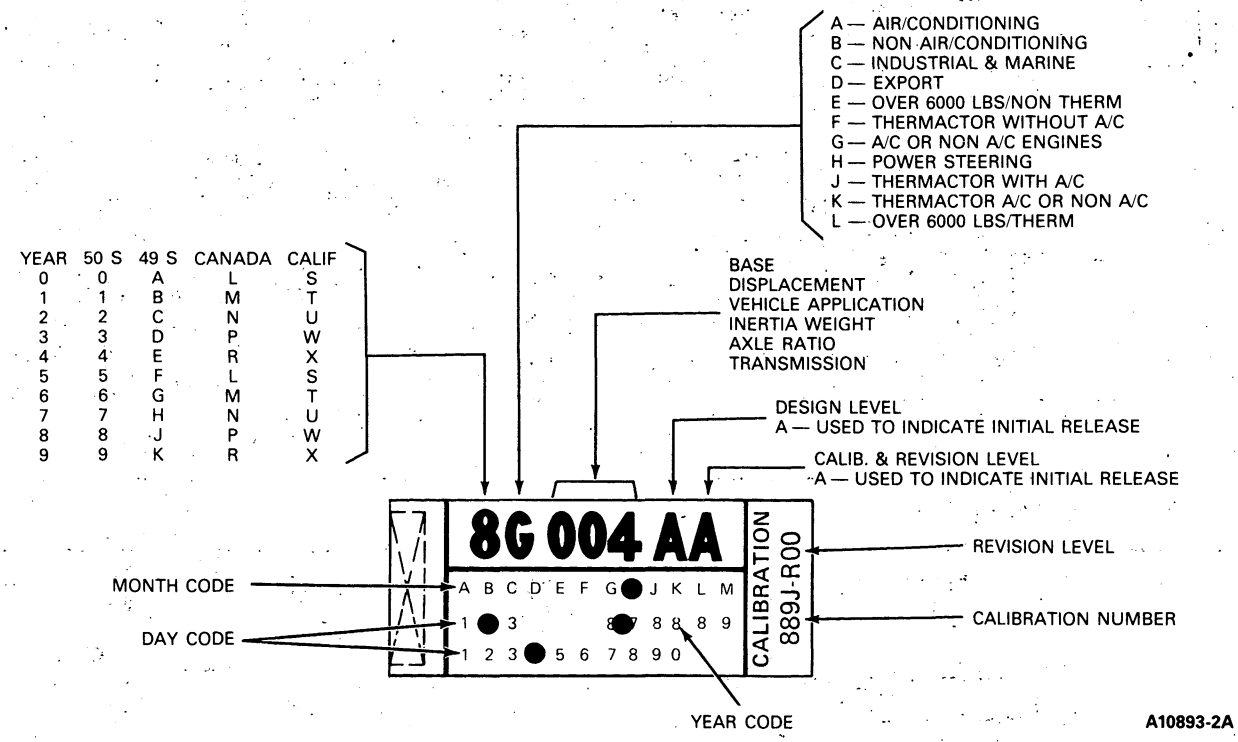


FIG. 16 Engine Code Label

3. Cooler bundle (tube)

NOTE: Prior to each retest, inspect the condition of the affected header gasket(s) and O-rings and replace if damaged.

9. Assemble the affected test kit cover plate(s) and tie bar. Repeat Steps 4 and 5 with cooler assembly submerged in water. If leak persists, replace the next component listed in Step 8. If no leakage was observed, go to Step 12.

10. For a leaking oil cooler not covered by warranty, replace and test the following oil cooler components in the following sequence until no leakage is observed:

    1. Cooler bundle (tube)
    2. Front header
    3. Rear header

NOTE: Prior to each retest, inspect the condition of the affected header gasket(s) and O-rings, replace if damaged.

11. Assemble the affected test kit cover plate(s) and tie bar. Repeat Steps 4 and 5 with cooler assembly submerged in water. If leak persists, replace the next component listed in Step 8. If no leakage was observed, go to Step 12.

12. Install oil cooler assembly onto engine with new gaskets as outlined.

NOTE: Clean the cooling system if oil is found in the coolant. Refer to Section 27-02, Cooling System Service. If coolant is found in the oil, change the oil and filter.

Compression Test

The following procedure is to be used when checking compression:

1. Ensure battery is fully charged. Operate the engine until normal operating temperature is attained. Turn the ignition switch to OFF. Remove air cleaner and/or intake opening cover using Intake Manifold Cover T83T-9424-A or equivalent. Disconnect injection pump solenoid leads from injection pump to prevent accidental engine starting. Remove all glow plugs.
2. Install Rotunda Compression Tester 014-00701 or equivalent in No. 1 cylinder glow plug hole.
3. Crank the engine (with the ignition switch OFF) at least five pumping strokes. Record highest reading indicated. Note the approximate number of

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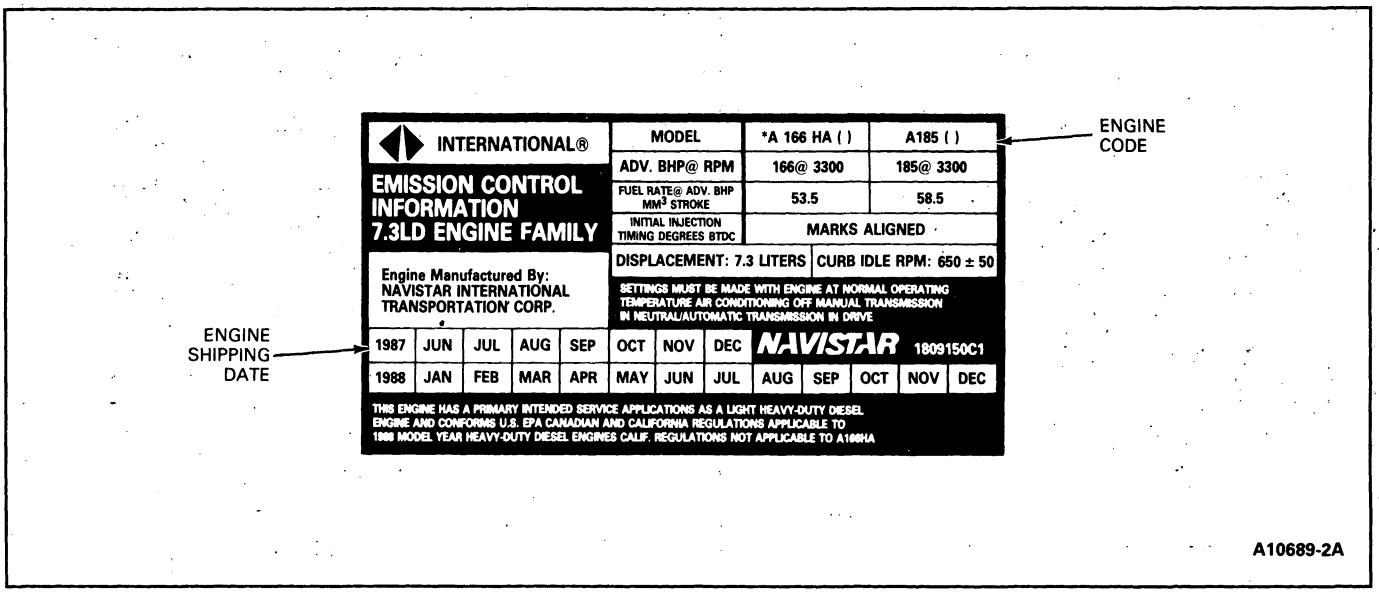


FIG. 17 Engine Emission Label

compression strokes required to obtain the highest reading.

4. Repeat the check on each cylinder, cranking the engine approximately the same number of compression strokes.

Test Conclusion

Compression pressures are considered normal if the lowest reading cylinder is within 75 percent of the highest. Variations exceeding 75 percent indicate an improperly seated valve or worn or broken piston rings (Refer to Fig. 22).

CAUTION: Do not add oil to cylinder. This could cause hydrostatic lock.

Hydraulic Valve Tappet

Hydraulic tappet noise may be caused by any of the following:

1. Excessive collapsed tappet gap.
2. Sticking tappet plunger.
3. Tappet check valve not functioning properly.
4. Air in lubrication system.
5. Leakdown rate too rapid.
6. Excessive valve guide wear.

Excessive collapsed tappet gap may be caused by loose rocker arm fulcrum bolts, or wear of tappet roller, push rod, rocker arm, rocker arm fulcrum or valve tip. Using Tappet Bleed-Down Wrench T83T-6500-A or

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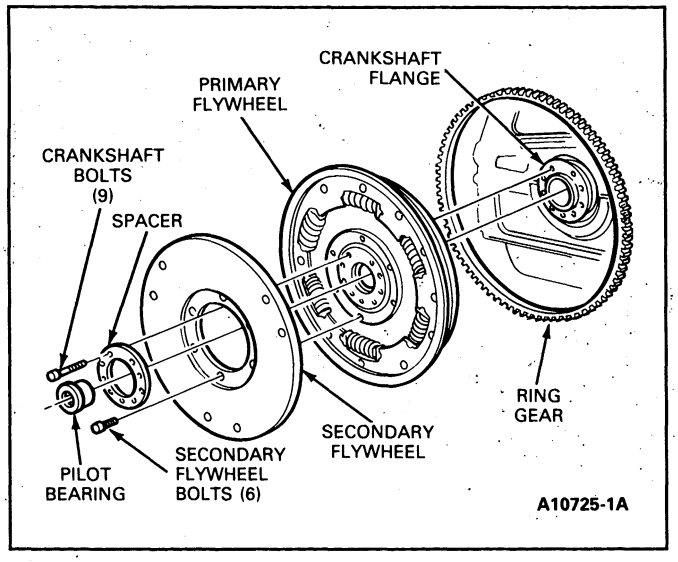


FIG. 18 Dual Mass Flywheel

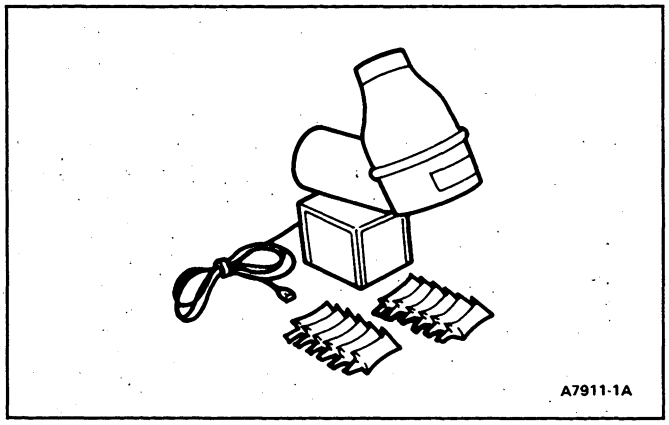


FIG. 19 Leak Test Kit Rotunda Model 112-00001

equivalent, collapse tappet and check gap between valve tip and rocker arm to determine if any valve train parts are damaged, worn, or out of adjustment.

A sticking tappet plunger may be caused by dirt, chips, or varnish inside the tappet. Sticking plungers can sometimes be serviced by disassembling the tappet and removing the dirt, chips or varnish causing the condition.

A non-functional tappet check valve may be caused by an obstruction (dirt or chips) preventing it from closing when the cam lobe is lifting the tappet. Non-functional tappet check valves may also be caused by a broken check valve spring.

Air bubbles in the lubrication system prevent the tappet from supporting the valve spring load. Bubbles may be caused by too high or too low an oil level in the oil pan, by air being drawn into the system through a hole or crack, or a leaking gasket on the oil pump pickup tube.

If leakdown time is below specifications for used tappets, noisy operation may result. If no other cause for noisy tappets can be found, check leakdown rate and replace any outside the specification.

Check leakdown rate of assembled tappets with Hydraulic Tappet Leakdown Tester TOOL-6500-E or equivalent. The leakdown rate specification is the time in seconds the plunger requires to move a specified

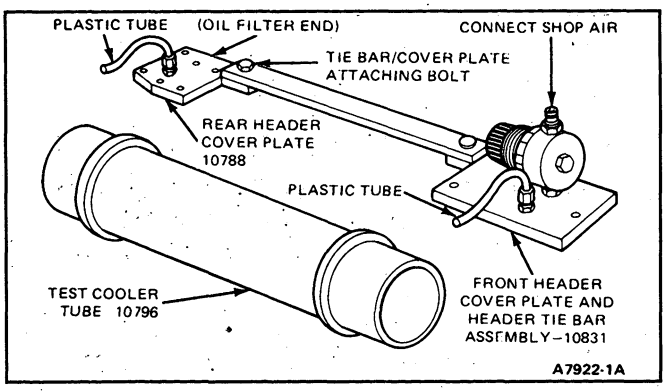


FIG. 20 Oil Cooler Internal Leakage Test Equipment Rotunda Model 014-00726

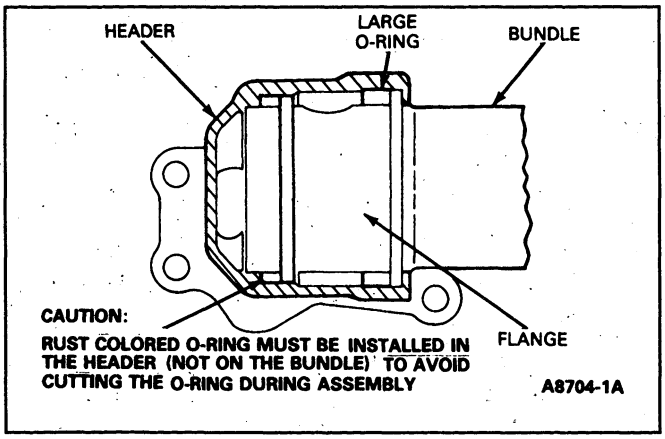


FIG. 21 Oil Cooler Tube Installed in Header

HIGHEST CYLINDER	LOWEST CYLINDER
Maximum kPa (PSI)	Minimum kPa (PSI)
1792 (260)	1344 (195)
1929 (280)	1447 (210)
2067 (300)	1551 (225)
2205 (320)	1654 (240)
2343 (340)	1757 (255)
2481 (360)	1860 (270)
2619 (380)	1964 (285)
2756 (400)	2067 (300)
2894 (420)	2171 (315)
3032 (440)	2274 (330)

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FIG. 22 Compression Test Pressures

distance of its travel while under a 22.68 kg (50 lb) load. Test the tappets as follows:

1. Disassemble and clean tappet to remove all traces of engine oil.

   NOTE: Do not mix parts from different tappets.

   Parts are select-fitted and are **NOT** interchangeable.

   Tappets cannot be checked with engine oil in them. Only testing fluid can be used.

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2. Place the tappet in tester, with plunger facing upward. Pour hydraulic tappet tester fluid into the cup to a level that will cover tappet assembly. The fluid can be purchased from the manufacturer of the tester.

   NOTE: Using kerosene or any other fluid will not provide an accurate test.

3. Place the 5/16-inch steel ball provided with tester into the plunger cap (Fig. 23).

4. Adjust ram length (Fig. 24) so that the pointer is 1.59mm (1/16 inch) below the starting mark when ram contacts tappet plunger, to facilitate timing as the pointer passes the Start Timing mark. Use center mark on the pointer scale as Stop Timing point instead of original Stop timing mark at top of scale.

5. Work the tappet plunger up and down until tappet fills with fluid and all traces of air bubbles have disappeared.

6. Allow ram and weight to force tappet plunger downward. Measure the exact time it takes for the pointer to travel from Start Timing to Stop Timing marks of tester.

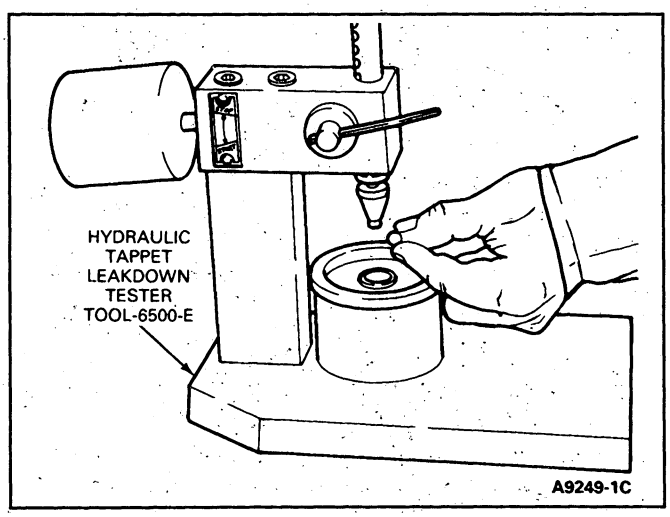


FIG. 23 Placing Steel Ball in Valve Tappet Plunger Cap

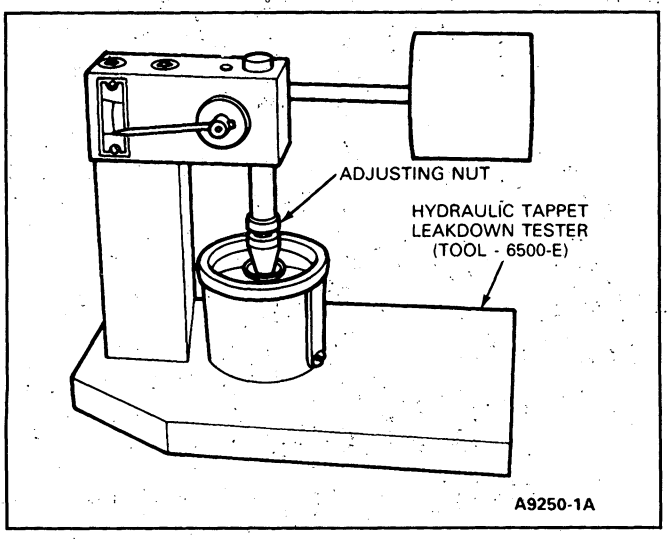


FIG. 24 Adjusting the Ram Length

7. A satisfactory tappet must have a leakdown rate (time in seconds) within the minimum and maximum specified limits.

8. If tappet leakdown is not within specifications, replace it with a new tappet. It is not necessary to disassemble and clean new tappets before testing, because the oil contained in new tappets is test fluid.

9. Remove fluid from cup and bleed fluid from tappet by working plunger up and down. This step will ease depression of tappet plungers when checking valve clearance.

Static (Engine Off) Valve Train Analysis

Rocker Arm Cover Removal

1. Remove air cleaner and install intake opening cap using Intake Manifold Cover T83T-9424-A, or equivalent.
2. Remove engine oil dipstick tube fasteners. Remove dipstick, tube assembly and rocker arm cover bracket.
3. Remove rocker arm cover bolts.
4. Remove rocker arm cover.

Valve Train Analysis

Check for damaged and/or severely worn parts, for correct assembly and use of correct parts by proceeding, as follows, with the static engine analysis (Fig. 25).

1. Rocker Arm Assemblies
   a. Check for loose mounting bolts.
   b. Check for plugged rocker arm oil hole.
2. Push Rods: Check for bent push rods. Check for clogged passages.
3. Valve Spring Assembly—With Damper Spring: Check for broken or damaged parts.
4. Retainer and Keys: Check for proper seating of keys on valve stem in retainer.
5. Positive Valve Rotator: Check for proper seating of the positive valve rotator.
6. Valves and Cylinder Head

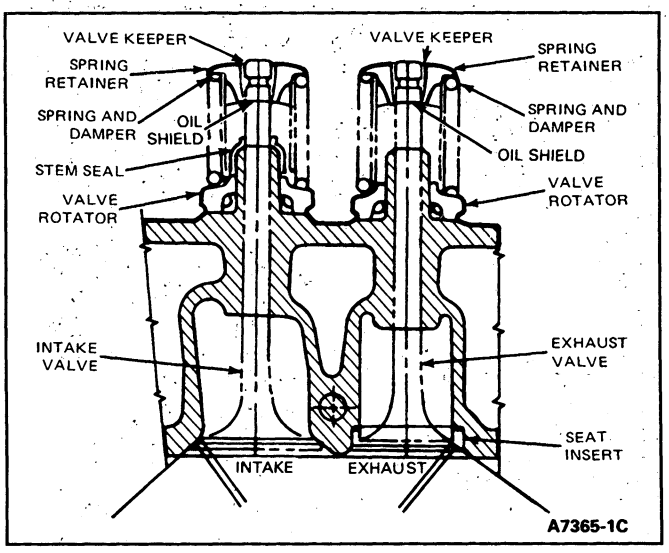


FIG. 25 Valve Spring Assembly

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a. Check cylinder head gasket for proper installation.
b. Check for plugged oil drain holes.
c. Check for worn or damaged valve tips.
d. Check for missing or damaged valve stem oil seals.
e. Check collapsed tappet gap.

Rocker Arm Cover Installation

1. Remove old gasket from cover. Scrape both valve cover rail on cylinder head and gasket flange on cover to remove all traces of old gasket, if necessary.
2. Install new gasket and install rocker arm cover onto engine. Tighten bolts to specification.
3. Install engine oil dipstick tube, valve cover bracket and cover. Tighten to specification. Install engine oil dipstick.
4. Remove intake manifold cover. Install air cleaner and tighten to specification.

Camshaft Lobe Lift

Check lift of each lobe (in consecutive order) and make a note of readings.

1. Remove fresh air inlet tube and air cleaner and install Intake Manifold Cover T83T-9424-A or equivalent.
2. Remove rocker arm cover(s) as outlined.
3. Remove fulcrum bolts, fulcrum seats and rocker arms as outlined.
4. Ensure push rod is in valve tappet socket. Install Dial Indicator with D78P-4201-G and Dial Indicator Bracketry Tool-4201-C D78P-4201-F or equivalent, so that indicator ball socket adapter using Cup Shaped Adapter TOOL-6565-AB or equivalent, is on the end of the push rod and in the same plane as push rod movement (Fig. 26).
5. Rotate crankshaft by hand until tappet is on base circle of crankshaft lobe. At this point, push rod will be in its lowest position.

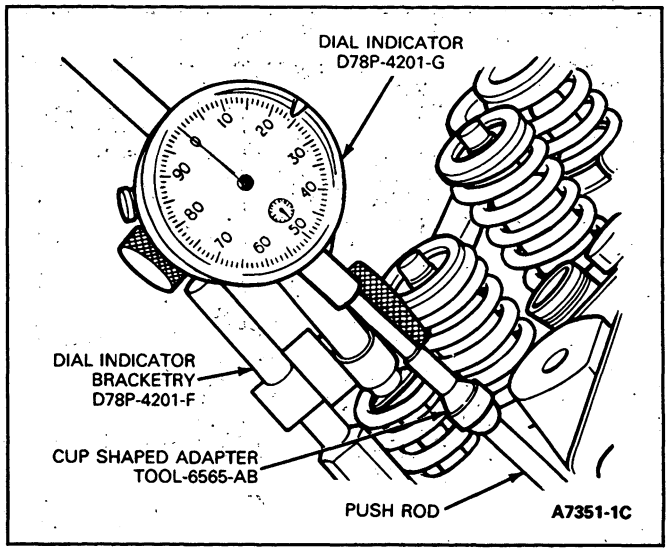


FIG. 26 Camshaft Lobe Lift Test

NOTE: Remove glow plugs with Glow Plug Socket D83T-6002-A, or equivalent, to facilitate turning engine over by hand.

6. Zero dial indicator. Continue to rotate crankshaft slowly until push rod is in fully raised position.
7. Compare total lift recorded on indicator with specification.
8. To check accuracy of original indicator reading, continue to rotate crankshaft until the indicator reads zero. If the lift on any lobe is below specified wear limits, the camshaft and the valve tappet operating on the worn lobe(s) must be replaced.
9. Remove the dial indicator.
10. Install rocker arms, fulcrum seats and fulcrum bolts as outlined. Tighten bolts to specification.
11. Install the valve cover(s) as described in this Section. Tighten bolts to specification.
12. Remove intake manifold cover, install air cleaner and tighten to specification.

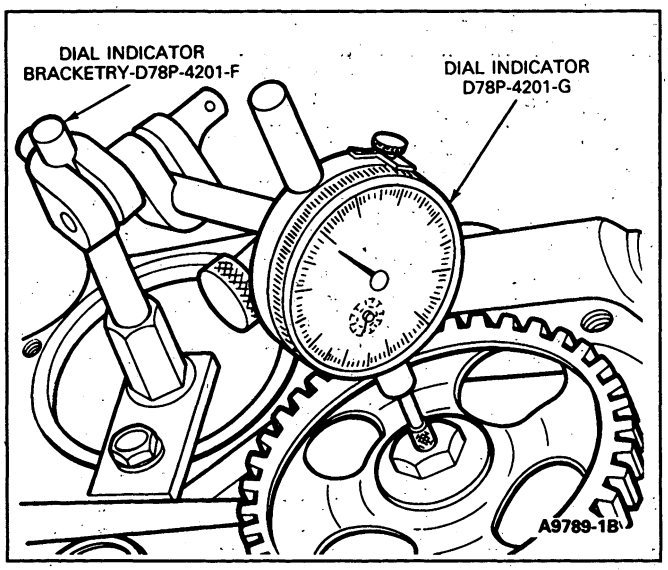


FIG. 27 Check Camshaft End Play—Typical

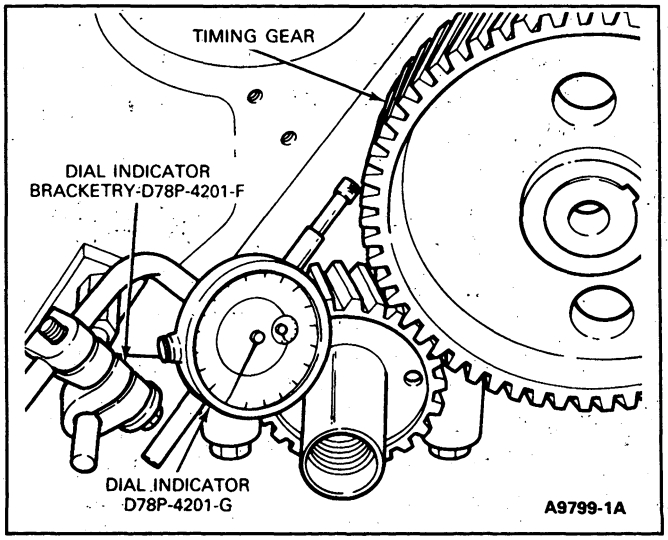


FIG. 28 Checking Drive Gear Backlash—Typical

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Camshaft End Play

Push the camshaft toward the rear of the engine. Install Dial Indicator Bracketry D78P-4201-F and Dial Indicator D78P-4201-G or equivalent, so that indicator point is on the camshaft gear attaching screw (Fig. 27). Zero the dial indicator. Position a large screwdriver between the camshaft gear and the block. Pull the camshaft forward and release it. Compare the dial indicator reading with specifications.

Remove the dial indicator. If end play is excessive, replace the camshaft thrust plate.

Drive Gear Backlash (All Gears)

Install Dial Indicator Bracketry D78P-4201-F and Dial Indicator D78P-4201-G or equivalent, on the cylinder block (Fig. 28). Check the backlash between the drive gear and the driven gear with a dial indicator at six equally spaced teeth. Hold the gear firmly against the block while making the check. Refer to Specifications for backlash limits.

Crankshaft End Play

1. Force the crankshaft toward the rear of the engine.
2. Install Dial Indicator Bracketry D78P-4201-F and Dial Indicator D78P-4201-G or equivalent, so that the contact point rests against the crankshaft flywheel flange and the indicator axis is parallel to the crankshaft axis (Fig. 29).
3. Zero the dial indicator. Push the crankshaft forward and note the reading on the dial.
4. If the end play exceeds specification, replace the thrust bearing. If the end play is less than the minimum limit, inspect the thrust bearing faces for scratches, burrs, nicks, or dirt. If the thrust faces are not damaged or dirty, they probably were not aligned properly. Lubricate and install the thrust bearing and align the faces following the procedure recommended under Main Bearing Replacement. Check the crankshaft end play.

Flywheel Runout—Manual-Shift Transmission

NOTE: Remove glow plugs with Glow Plug Socket D83T-6002-A, or equivalent, to facilitate turning engine over by hand.

Install Dial Indicator Bracketry D78P-4201-F and Dial Indicator D78P-4201-G or equivalent, so that the indicator point bears against the flywheel face, one inch from the edge of the flywheel (Fig. 30). Zero the dial indicator. Turn flywheel making sure it is fully forward or rearward so that crankshaft end play will not be indicated as flywheel runout.

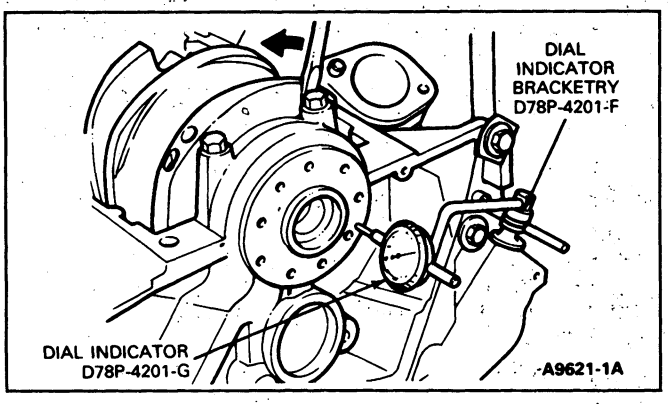


FIG. 29 Checking Crankshaft End Play

If flywheel clutch face runout exceeds specifications, remove flywheel. Check for burrs between flywheel and face of the crankshaft mounting flange. If no burrs exist, check crankshaft mounting flange runout. If crankshaft mounting flange face runout is excessive, machine mounting flange or replace crankshaft. If crankshaft mounting flange runout is not excessive, reface or replace secondary flywheel. If the ring gear runout exceeds specifications, check installation of gear to flywheel flange. If it is not properly seated, re-install it to flywheel. If it is properly seated, replace it. Refer to Ring Gear Replacement in this Section for applicable procedures.

Flywheel Runout—Automatic Transmission

Remove the glow plugs with Glow Plug Socket D83T-6002-A, or equivalent, to facilitate turning engine over by hand.

Install a dial indicator so that the indicator point rests on the ring gear face adjacent to the gear teeth.

Push the flywheel and crankshaft fully forward or rearward to prevent crankshaft end play from being indicated as flywheel runout.

Zero the dial indicator. Turn the flywheel one complete revolution while observing the total indicator reading (TIR). If TIR exceeds specifications, remove flywheel and check for burrs between flywheel and face of crankshaft mounting flange. If no burrs exist, check runout of crankshaft mounting flange. If crankshaft flange face exceeds specifications, machine mounting flange or replace crankshaft. If crankshaft flange face runout is not excessive, check installation of ring gear to flywheel. If not properly seated, remove and reinstall ring gear to flywheel. If ring gear is properly seated, replace flywheel.

Diagnostic Procedures—Engine Performance and Glow Plug System

Diagnostic procedures for engine performance, fuel injection and glow plug fast start system are covered in

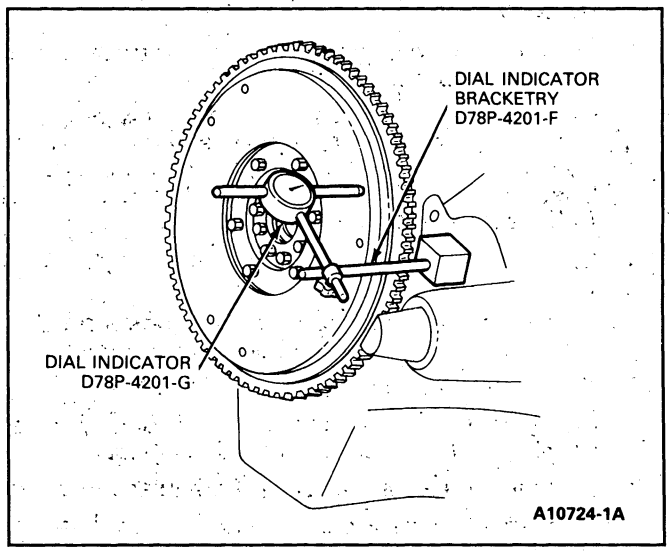


FIG. 30 Checking Flywheel Face Runout—Manual Transmission

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the Engine/Emissions Diagnosis Manual*. Injection pump timing and nozzle performance are also covered in the Engine/Emissions Diagnosis Manual*.

ADJUSTMENTS

Refer to Engine/Emissions Diagnosis Manual* for adjustment procedures.

REMOVAL AND INSTALLATION

When installing nuts or bolts that must be tightened, (refer to Torque Limits at the end of this Section), oil threads with light weight engine oil. **Do not oil threads that require oil-resistant or water resistant sealer.**

Engine Assembly

F-250-F-350 F-Super Duty Chassis Cab-Stripped Chassis

Removal

1. Disconnect battery ground cables from both batteries.
2. Scribe alignment marks at hood hinges for reference during installation. Remove hood.
3. Drain cooling system. Refer to Section 27-02, Cooling System Service.
4. Remove air cleaner and intake duct assembly.
5. Install Intake Manifold Cover T83T-9424-A, or equivalent, over air intake opening.
6. Remove radiator fan shroud. Refer to Section 27-04, Radiators.
7. Remove fan and clutch assembly as outlined, using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B or equivalent.

   CAUTION: LH thread. Remove by turning nut clockwise.
8. Disconnect radiator upper and lower hoses from radiator.
9. Disconnect automatic transmission oil cooler lines at radiator, if so equipped.
10. Remove radiator. Refer to Section 27-04, Radiators.
11. Loosen A/C compressor, if so equipped, and remove drive belt.
12. Remove A/C compressor, if so equipped, and position it on radiator upper support (refer to Section 36-61, F-150 through F-350, F-Super Duty Chassis Cab, Stripped Chassis and Bronco Manual A/C-Heater System).
13. Loosen power steering pump and remove drive belt.
14. Remove power steering pump and position out of the way on LH side of engine compartment.
15. Disconnect alternator wires at alternator.
16. Disconnect oil pressure sending unit wire at sending unit located at back of engine.
17. Disconnect accelerator cable from injection pump.
18. Disconnect speed control cable from injection pump, if so equipped.
19. Remove accelerator cable bracket (with cables attached), from intake manifold and position out of the way.
20. Disconnect transmission kick down rod from injection pump, if so equipped.
21. Disconnect main wiring harness connector from RH side of engine.
22. Disconnect engine ground strap from rear of engine.
23. Disconnect fuel return hose from LH rear of engine.
24. Remove vacuum supply hose from vacuum pump.
25. Remove two upper transmission-to-engine attaching bolts.
26. Disconnect heater hoses from water pump and right cylinder head.
27. Disconnect water temperature sender wire from sender on left front of engine block.
28. Disconnect water temperature overheat lamp switch wire from switch on top front of left cylinder head.
29. Position wires out of the way.
30. Raise vehicle.
31. Disconnect both battery ground cables from lower front of engine.
32. Disconnect and cap fuel inlet line at fuel supply pump.
33. Disconnect starter cables at starter motor.
34. Disconnect muffler inlet pipe at exhaust manifolds.
35. Disconnect engine insulators from No. 1 crossmember.
36. Remove flywheel inspection plate.
37. Remove four convertor-to-flywheel attaching nuts, if so equipped.
38. Lower vehicle.
39. Support transmission.
40. Remove four lower transmission-to-engine attaching bolts.
41. Attach Rotunda Universal Load Positioning Sling 014-00036 or equivalent to engine.
42. Raise engine high enough to clear number one crossmember and pull forward.
43. Rotate the front of the engine approximately 45 degrees to the left and lift it out of the engine compartment.

    CAUTION: Use care not to damage windshield wiper motor when lifting engine out of vehicle.

Installation

NOTE: If the engine to be installed has been overhauled or has been in storage, take the following precaution to prevent piston and bearing scuffing. Prime the entire engine lubricating system to fill the oil cooler, oil filter and cylinder block galleries with the specified type and grade of oil.

1. Lower engine into engine compartment.

*Can be purchased as a separate item.

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CAUTION: Use care not to damage windshield wiper motor when installing engine into vehicle.

2. Start transmission main shaft into clutch disc. It may be necessary to adjust position of transmission in relation to engine if main shaft binds or will not enter clutch disc. If engine hangs up after main shaft enters clutch disc, rotate crankshaft slowly (transmission in gear) until mainshaft splines mesh with clutch disc splines.
3. Align torque converter with flywheel studs, if so equipped.
4. Lower engine onto engine insulator brackets on number one crossmember.
5. Install four lower transmission-to-engine attaching bolts and tighten to specifications.
6. Remove engine lifting sling.
7. Raise vehicle.
8. Install four torque converter-to-flywheel attaching nuts, if so equipped, and tighten to specifications.
9. Install flywheel inspection plate and tighten bolts to specifications.
10. Install engine insulator support-to-crossmember bracket attaching nuts and washers and tighten to specifications.
11. Connect muffler inlet pipes to exhaust manifolds and tighten nuts to specifications.
12. Connect both battery ground cables to the lower front of the engine and tighten bolts to specifications.
13. Connect starter cables to starter and tighten to specifications.
14. Install fuel pump inlet line onto fuel pump and tighten to specifications.
15. Lower vehicle.
16. Connect water temperature sender wire to sender on left front of engine block.
17. Connect wire to water temperature overheat lamp switch on top of left cylinder head.
18. Install heater hoses onto right cylinder head and water pump and tighten clamps to specifications.
19. Connect engine ground strap at rear of engine.
20. Connect fuel return hose at left rear of engine.
21. Connect vacuum supply hose to vacuum pump.
22. Connect transmission kickdown rod, if so equipped.
23. Install accelerator cable bracket onto intake manifold and tighten to specifications.
24. Connect accelerator cable to injection pump.
25. Connect speed control cable, if so equipped, to injection pump.
26. Connect oil pressure gauge sender wire to oil pressure sender.
27. Connect alternator wires to alternator.
28. Install power steering pump and drive belt. Do not adjust belt at this time.
29. Install A/C compressor and drive belt. Refer to Section 36-61, F-150 Through F-350, F-Super Duty Chassis Cab, Stripped Chassis and Bronco Manual A/C-Heater System, in Body/Chassis/Electrical Manual.
30. Adjust A/C compressor and power steering pump drive belts to specifications. Refer to Section 27-06, Accessory Drive Belt Service.
31. Install radiator. Refer to Section 27-04, Radiators.
32. Connect automatic transmission oil cooler lines at radiator, if so equipped. Tighten line nuts to specifications.
33. Connect upper and lower radiator hoses to radiator and tighten hose clamps to specifications.
34. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service.
35. Install fan and clutch assembly using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B or equivalent.

    CAUTION: LH thread. Turn nut counterclockwise to tighten.

    Tighten nut to specifications.
36. Install radiator fan shroud. Refer to 27-04, Radiators.
37. Remove intake manifold cover. Install air cleaner and tighten to specifications.
38. Install intake duct assembly.
39. Install hood, aligning scribe marks drawn on hood during removal.
40. Connect battery ground cables at both batteries.
41. Check the engine oil level and fill as needed with specified type and grade of oil.
42. Run engine and check for fuel, oil and coolant leaks.

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Removal

The engine removal and installation procedures are for the engine only (transmission not attached).

1. Remove engine cover.
2. Disconnect ground cables from both batteries.
3. Drain cooling system. Refer to Section 27-02, Cooling System Service.
4. Remove front bumper, grille assembly and gravel deflector.
5. Remove speed control servo bracket and position out of way (if so equipped).
6. Mark location and remove hood latch and cable assembly from grille upper support bracket.
7. Remove upper grille support.
8. Discharge the A/C system, if so equipped. Refer to Section 36-65, E-150 — E-350 Air Conditioning System, in Body/Chassis/Electrical Shop Manual.
9. Disconnect A/C lines from A/C condenser, if so equipped.
10. Remove A/C condenser, if so equipped.
11. Disconnect transmission oil cooler lines at transmission oil cooler and radiator.
12. Remove transmission oil cooler and brackets.
13. Disconnect radiator hoses at engine.

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14. Remove radiator shroud. Refer to Section 27-04, Radiators.
15. Remove radiator cooling fan using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B, or equivalent.

    CAUTION: LH thread. Remove by turning nut clockwise.
16. Support radiator. Install lifting hooks in lifting eyes on radiator.
17. Remove radiator attaching bolts from bottom of radiator and lift radiator out of vehicle.
18. Loosen and remove vacuum pump and drive belt. Disconnect vacuum hose from transmission shift modulator tube.
19. Loosen and remove alternator adjusting arm, adjusting arm bracket and drive belt. Pivot alternator inward toward engine.
20. Disconnect alternator wiring harness from alternator.
21. Disconnect water temperature sender wire from sender on left front of engine block.
22. Disconnect water temperature overheat lamp switch wire from switch on top front of left cylinder head.
23. Position wires out of the way.
24. Remove two engine ground cables from bottom front of engine.
25. Remove power steering pump and bracket from engine.
26. Disconnect and plug power steering pump return line.
27. Position power steering pump out of the way.

    NOTE: Refrigerant system must be discharged prior to line removal. Refer to Group 36 for applicable procedures.
28. Remove A/C lines at A/C compressor.
29. Remove vacuum hose between vacuum regulator valve (VRV) and injection pump and position out of the way.
30. Disconnect and cap fuel heater inlet line at fuel filter and fuel pump.
31. Remove air cleaner assembly and inlet duct.
32. Cover air intake opening with Intake Manifold Cover T83T-9424-A or equivalent.
33. Disconnect and cap fuel filter outlet line at fuel filter and injection pump. Cap injection pump and fuel filter fittings.
34. Remove fuel filter return hose.
35. Remove fuel filter and bracket from engine as an assembly.
36. Loosen A/C compressor and rotate toward engine.
37. Remove and plug fuel inlet hose at fuel pump.
38. Remove accelerator and speed control cables from injection pump and bracket on intake and position out of the way. Remove cable bracket.
39. Disconnect engine wiring harnesses from inside vehicle and position out of the way.
40. Remove transmission kickdown rod.
41. Disconnect heater hose from water pump and right cylinder head.
42. Remove auxillary heater and A/C hoses from bracket at left rear of engine, if so equipped.
43. Disconnect oil pressure sender wire from sender on rear of engine.
44. Disconnect fuel return line from left rear of engine.
45. Remove transmission oil dipstick tube attaching bolt from rear of right cylinder head.
46. Remove engine oil dipstick tube attaching nut from right exhaust manifold. Remove screw from valve cover bracket and remove dipstick and dipstick tube.
47. Remove the bolt attaching ground cable to cylinder block.
48. Remove top four transmission-to-engine attaching bolts.
49. Raise vehicle.
50. Remove the engine mount attaching nuts.
51. Disconnect the muffler inlet pipe at the exhaust manifolds.
52. Remove the converter inspection plate.
53. Remove the four converter-to-flywheel attaching nuts.
54. Remove the starter cable.
55. Position fuel line on No. 1 crossmember down and out of the way.
56. Lower the vehicle.
57. Install Rotunda Engine Lifting Bracket 014-00312 or equivalent.
58. Support transmission and remove the remaining transmission-to-engine attaching bolts.
59. Separate engine from transmission, raise engine high enough to clear number one crossmember, then pull engine forward and out of vehicle.

Installation

NOTE: If the engine to be installed has been overhauled or has been in storage, take the following precaution to prevent piston and bearing scuffing. Prime the entire engine lubricating system to fill the oil cooler, oil filter and cylinder block galleries with the specified type and grade of oil.

1. Lower engine into engine compartment.
2. Align torque converter with flywheel studs.
3. Position transmission and install two lower transmission-to-engine attaching bolts. Tighten transmission-to-engine attaching bolts to specification.
4. Remove engine lifting bracket.
5. Raise the vehicle.
6. Install the starter cable and tighten to specification.
7. Install the four converter-to-flywheel attaching nuts and tighten to specification.
8. Install the converter inspection plate and tighten to specification.
9. Connect the muffler inlet pipe to the exhaust manifolds and tighten to specification.

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10. Install the engine mount attaching nuts and tighten to specification.
11. Position fuel line on No. 1 crossmember.
12. Lower vehicle.
13. Install the top four transmission-to-engine attaching bolts and tighten to specification.
14. Position engine oil dipstick to right exhaust manifold and valve cover bracket. Install dipstick attaching fasteners and tighten to specification. Install dipstick into dipstick tube.
15. Position transmission oil dipstick tube to rear of right cylinder head and install attaching bolt. Tighten to specification. Install dipstick into dipstick tube.
16. Connect fuel return line at left rear of engine and tighten to specification.
17. Connect battery ground cable to engine block.
18. Connect auxiliary heater and A/C hoses to bracket at left rear of engine, if so equipped.
19. Install heater hoses on right cylinder head and water pump and tighten clamps to specifications.
20. Install transmission kickdown rod.
21. Connect engine wiring harness to inside of passenger compartment.
22. Connect oil pressure sender wire to sender at rear of engine.
23. Install accelerator cable bracket to intake manifold. Install accelerator and speed control cables to bracket and the injection pump.
24. Remove plug from fuel inlet hose at fuel pump and install hose to fuel pump. Tighten clamp to specification.
25. Install fuel filter and bracket to engine.
26. Remove caps from fuel filter, outlet line and injection pump. Install line between fuel filter outlet and injection pump.
27. Connect fuel filter return hose.
28. Remove intake manifold cover and install air cleaner and inlet duct assembly.
29. Connect fuel line between fuel filter inlet and fuel pump.
30. Install vacuum hose between vacuum regulator valve (VRV) and injection pump.
31. Connect water temperature sender wire to sender on left front of engine block.
32. Connect wire to water temperature overheat lamp switch on top of left cylinder head.
33. Install A/C lines and A/C drive belt to the A/C compressor. Refer to Section 36-65, E-150 Through E-350 Air Conditioning System, in the Body/Chassis/Electrical Shop Manual.
34. Remove plug from power steering pump return line and install return line hose.
35. Install power steering pump drive belt and bracket.
36. Install two engine ground cables to bottom front of engine.
37. Connect alternator wiring harness to alternator and fuel line heater.
38. Loosely attach alternator adjusting arm and adjusting bracket to alternator and engine. Install drive belt.
39. Loosely install vacuum pump to engine. Install vacuum pump drive belt and connect vacuum hose transmission shift modulator tube.
40. Adjust all accessory drive belt to specifications. Refer to Section 27-06, Accessory Drive Belt Service.
41. Position radiator into engine compartment and install radiator attaching bolts.
42. Install radiator cooling fan.

    CAUTION: LH thread. Tighten nut by turning counterclockwise.
43. Install radiator shroud. Refer to Section 27-04, Radiators, in this Manual.
44. Connect radiator hoses to engine.
45. Install transmission oil cooler and brackets and tighten to specifications.
46. Connect transmission oil cooler lines to transmission oil cooler and radiator.
47. Install A/C condenser, if so equipped. Refer to Section 36-65, E-150 Through E-350 Air Conditioning System, in the Body/Chassis/Electrical Shop Manual.
48. Connect A/C lines to A/C condenser, if so equipped.
49. Charge the A/C system. Refer to Section 36-65, E-150 Through E-350 Air Conditioning System, in the Body/Chassis/Electrical Shop Manual.
50. Install upper grill support.
51. Install hood latch and cable assembly to grille upper support bracket.
52. Install speed control servo bracket, if so equipped.
53. Install front bumper, grille assembly and gravel deflector.
54. Fill and bleed cooling system. Refer to Section 27-02, Cooling System Service.
55. Connect ground cables to both batteries.
56. Check the engine oil level and fill as needed with the specified type and grade of oil.
57. Run engine and check for fuel, oil and coolant leaks.
58. Install engine cover.

Engine Front Insulators

F-250—F-350 F-Super Duty Chassis Cab and Stripped Chassis

Removal

1. Disconnect ground cables from both batteries.
2. Remove fan shroud halves. Refer to Section 27-04, Radiators.
3. Raise vehicle.
4. Remove nuts attaching insulators to crossmember (Figs. 31 and 32).
5. Disconnect muffler inlet pipes at exhaust manifolds.
6. Remove bolts attaching insulators to engine block.

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7. Lower vehicle.
8. Install Rotunda Universal Load Positioning Sling 014-00036 or equivalent, to lifting eyes on engine and raise engine high enough for insulators to clear crossmember.
9. Remove insulator and bracket assemblies.
10. Remove insulator from bracket.

Installation

1. Install insulator onto insulator bracket and tighten to specifications (Figs. 31 and 32).
2. Install insulator and bracket assembly onto engine block and tighten to specifications.
3. Lower engine onto crossmember.
4. Remove lifting sling.
5. Raise vehicle.
6. Install insulator-to-crossmember attaching nuts and washers and tighten to specifications.
7. Lower vehicle.
8. Install radiator fan shroud. Refer to Section 27-04, Radiators.
9. Connect ground cables to both batteries.

Removal

E-250—E-350

1. Disconnect battery ground cables from both batteries.
2. Remove radiator fan shroud. Refer to Section 27-04, Radiators.
3. Loosen vacuum pump and remove vacuum pump drive belt.
4. Loosen alternator and remove alternator drive belt.
5. Disconnect alternator wiring harness from alternator.
6. Remove alternator adjusting bracket.
7. Remove alternator through bolt and remove alternator from engine.

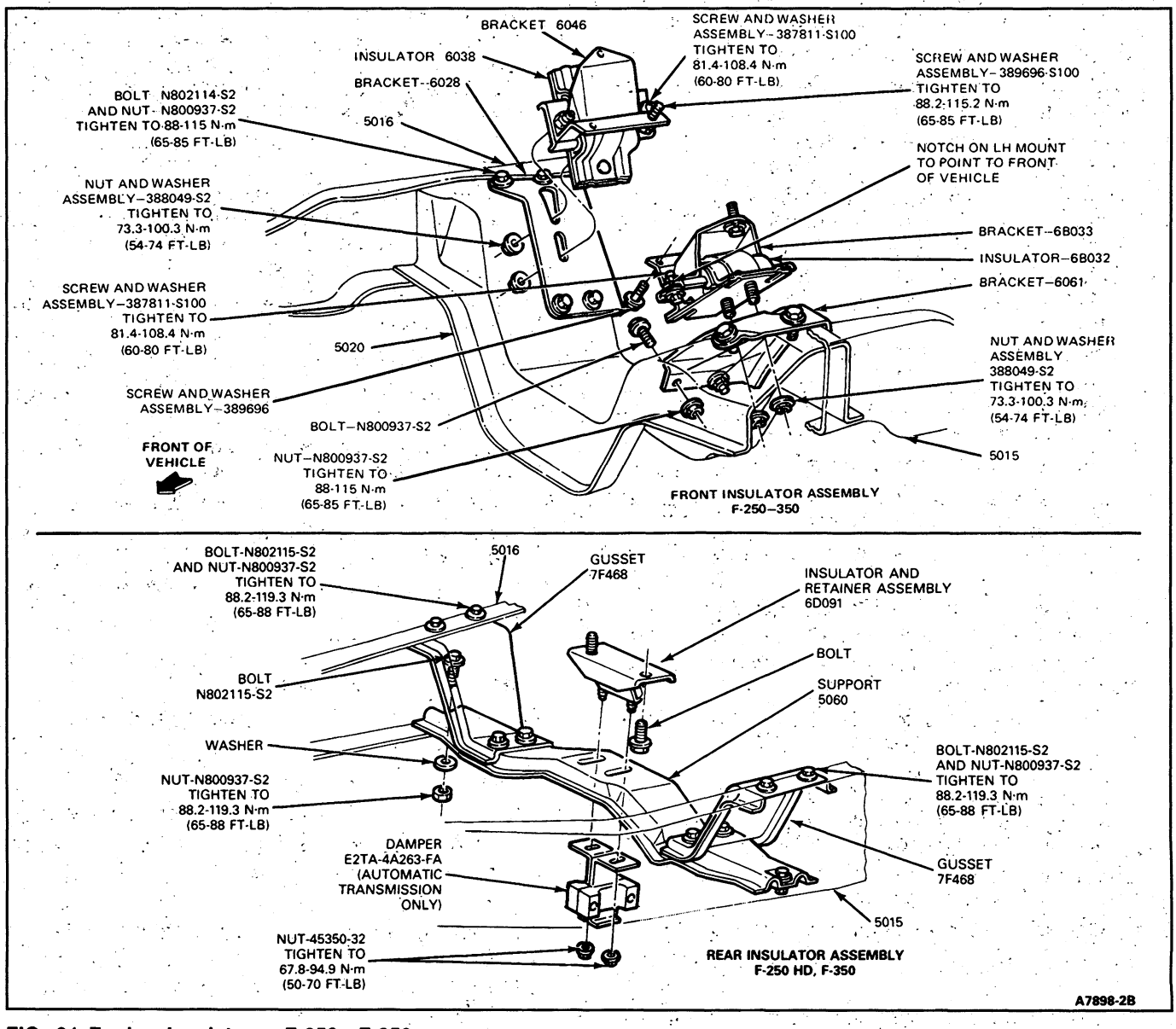


FIG. 31 Engine Insulators—F-250—F-350

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8. Remove fuel filter/fuel heater/water separator inlet line from fuel pump and fuel filter.
9. Discharge the A/C system, if so equipped. Refer to Section 36-65, E-150—E-350, Air Conditioning System in the Body/Chassis/Electrical Shop Manual.
10. Remove A/C hoses, if so equipped (refer to Section 36-65, E-150 Through E-350 Air Conditioning System).
11. Remove A/C compressor and bracket, if so equipped. Refer to Section 36-65, E-150 Through E-350 Air Conditioning System.
12. Remove engine cover.
13. Remove air cleaner and install Intake Manifold Cover T83T-9424-A, or equivalent, over air intake opening.
14. Remove and cap fuel filter/fuel heater/water separator to injection pump fuel line. Cap injection pump and fuel filter fittings.
15. Remove fuel filter/fuel heater/water separator return line hose.
16. Remove fuel filter/fuel heater/water separator bracket attaching bolts and remove filter and bracket as an assembly.
17. Remove kickdown rod from injection pump.
18. Raise vehicle.

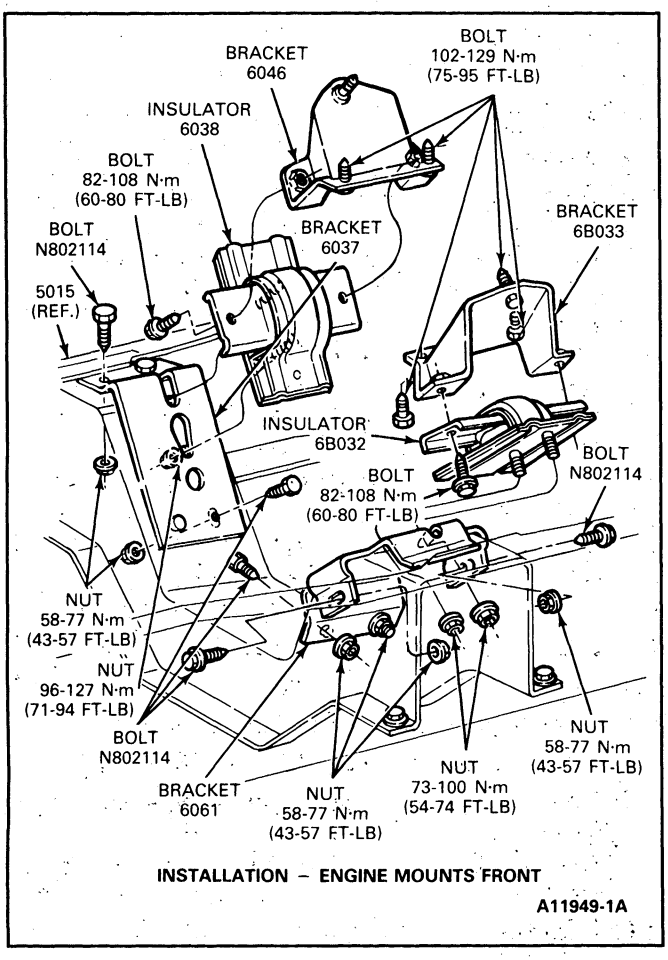


FIG. 32 Engine Insulators—F-Super Duty Commercial Stripped Chassis Vehicles

19. Disconnect ground cables from lower front of engine.
20. Remove nuts attaching insulators to No. 1 crossmember (Fig. 33).
21. Disconnect and remove transmission kickdown rod from transmission.
22. Lower vehicle.

NOTE: If engine has no lifting eye on RH rear side, move LH rear lifting eye to RH side. Use a 3-inch bolt to attach eye to RH side.

23. Install Rotunda Engine Lifting Brackets 014-00312 or equivalent, to front of engine. Attach turn buckle to RH rear lifting eye.
24. Raise engine until it contacts body.
25. Remove insulator and bracket assemblies.

Installation

1. Install insulator to bracket and tighten to specifications (Fig. 33).
2. Install insulator and bracket assembly onto engine and tighten to specifications.
3. Lower engine.
4. Remove turnbuckle from RH rear lifting eye and remove lifting bracket from front of engine.
5. Transfer lifting eye from RH side to LH side if removed. Install original manifold bolts and tighten to specification.
6. Raise vehicle.
7. Install insulator to crossmember No. 1 with attaching nuts and tighten to specifications.
8. Install transmission kickdown rod and connect to transmission.
9. Install engine ground cables and tighten to specification.
10. Lower vehicle.
11. Install fuel filter/fuel heater/water separator and bracket assembly and tighten to specification.
12. Uncap and install fuel filter/fuel heater/water separator to injection pump fuel line.
13. Install fuel filter/fuel heater/water separator return hose and clamp.
14. Remove intake opening cover. Install air cleaner and tighten to specifications.
15. Install A/C compressor and bracket, if so equipped, and tighten to specifications. Refer to Section 36-65, E-150 Through E-350 Air Conditioning System in the Body/Chassis/Electrical Shop Manual.
16. Install A/C hoses (refer to Section 36-65, E-150 Through E-350 Air Conditioning System), if so equipped.
17. Install A/C compressor drive belt, if so equipped.
18. Install fuel pump to fuel filter/fuel heater/water separator line and tighten to specification.
19. Install alternator and alternator adjusting bracket.
20. Install alternator drive belt.
21. Install alternator wiring onto alternator.
22. Install vacuum pump drive belt on alternator pulley.

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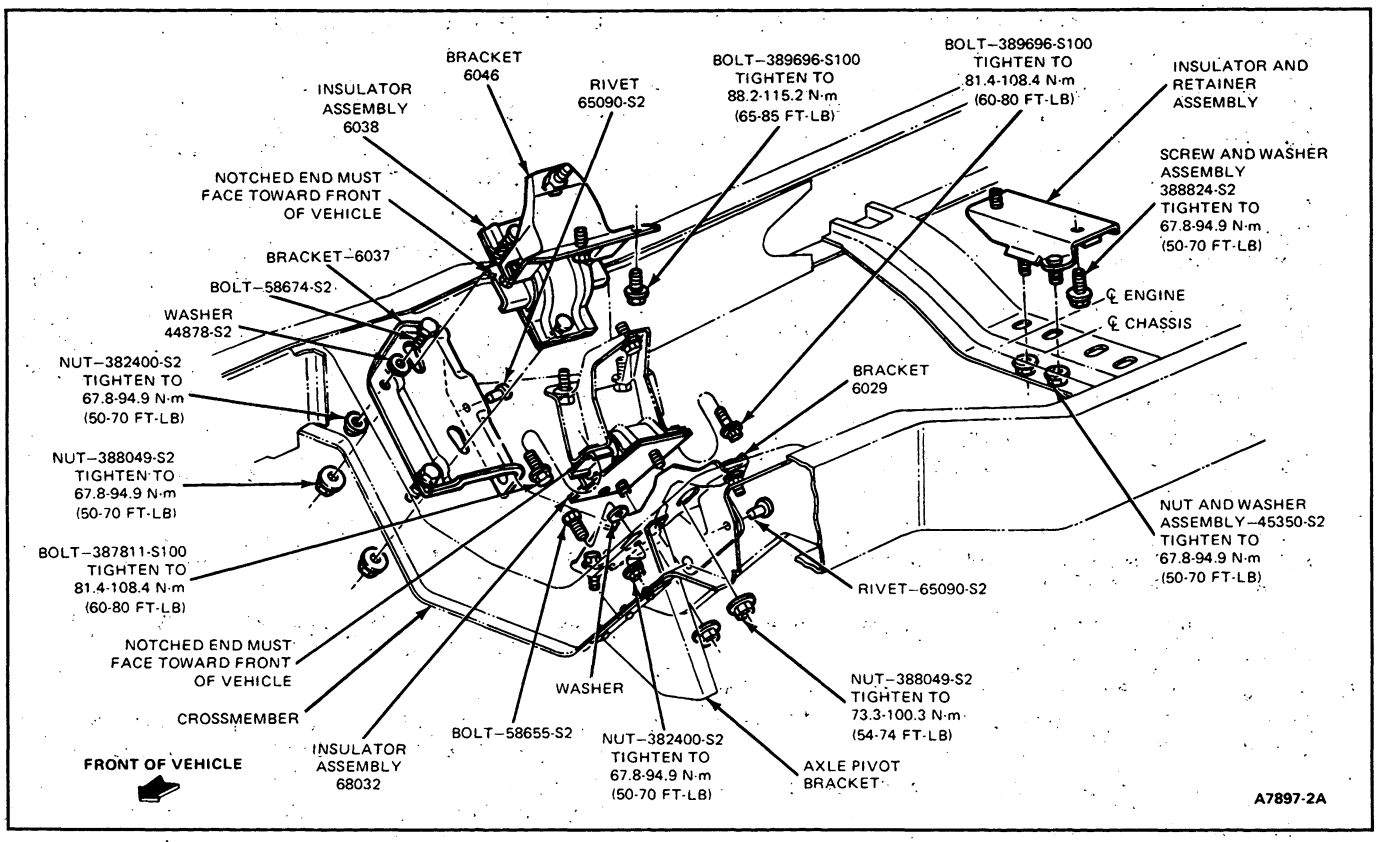


FIG. 33 Engine Insulators—E-250—E-350

23. Adjust A/C compressor, alternator, and vacuum pump drive belts to specification. Refer to Section 27-06 Accessory Drive Belt Service.
24. Install fan and clutch assembly and tighten to specifications. Refer to Section 27-04, Radiators.
25. Install fan shroud. Refer to Section 27-04, Radiators.
26. Evacuate and charge A/C system, if so equipped. Refer to Section 36-65, E-150 Through E-350 Air Conditioning System in the Body/Chassis/ Electrical Manual.
27. Connect battery ground cables to both batteries.
28. Install engine cover.

Engine Rear Insulator

Removal

1. Remove the insulator-to-support assembly bolt and locknut (Figs. 33 and 34).
2. Remove the insulator-to-transmission housing bolts and lockwashers.
3. Raise the transmission with a floor jack and remove the insulator and retainer.

Installation

1. Position the insulator and retainer to the transmission housing and install the attaching bolts and lockwashers, using the holes noted on removal (Figs. 33 and 34). Tighten to specifications.
2. Lower the transmission and remove the jack.
3. Install the insulator-to-support assembly bolt and locknut. Tighten to specification.
4. Lower the vehicle.

Water Pump

Removal

1. Disconnect battery ground cables from both batteries.
2. Drain cooling system. Refer to Section 27-02, Cooling System Service.
3. Remove radiator fan shroud halves. Refer to Section 27-04, Radiators.
4. Remove fan and clutch assembly using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B, or equivalent.

   CAUTION: LH thread: Remove by turning nut clockwise (Fig. 33).
5. Loosen power steering pump and A/C compressor. Remove drive belts.
6. Loosen vacuum pump and remove drive belt.
7. Loosen alternator and remove drive belt.
8. Remove water pump pulley.
9. Disconnect heater hose from water pump.
10. Remove heater hose fitting from water pump.
11. Remove alternator adjusting arm and adjusting arm bracket.
12. Remove A/C compressor and position out of the way.
13. Remove A/C compressor brackets.
14. Remove power steering pump and bracket and position out of the way.

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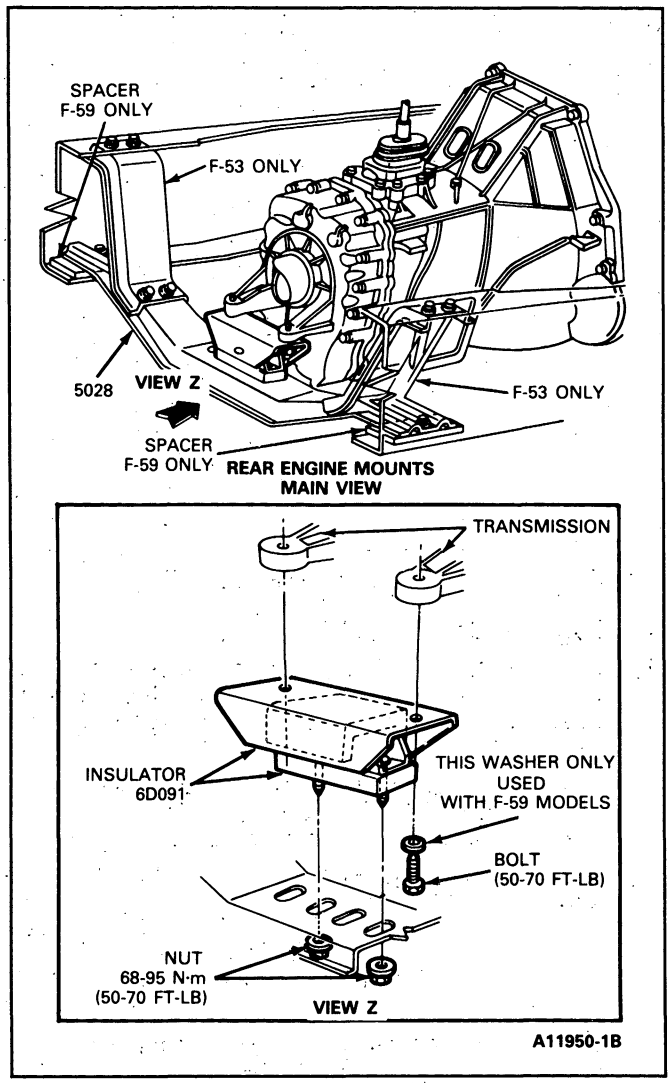


FIG. 34 Engine Insulators—F-Series Stripped Chassis

15. Remove bolts attaching water pump to front cover and remove pump.

Installation

1. Clean water pump and engine front cover mating surfaces with suitable solvent. Clean bolt threads.

   NOTE: Coat two top bolts and two bottom bolts with Aviation Permatex TM No. 3 or equivalent before installation. Install bolts within five minutes of sealer application. Ensure that correct length bolts are installed in correct holes (Fig. 34).

2. Install water pump with new gasket and tighten to specifications.
3. Install alternator adjusting arm bracket and tighten to specifications.
4. Install water pump pulley and tighten to specification.
5. Coat heater hose fitting with Pipe Sealant with Teflon® D8AZ-19554-A or equivalent, and install in water pump. Tighten to specifications.
6. Connect heater hose to water pump and tighten clamp to specifications.
7. Install power steering pump bracket and tighten to specification.

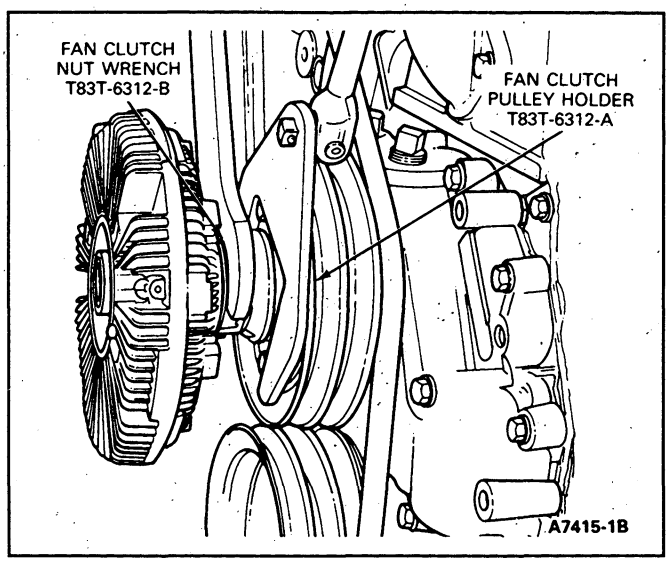


FIG. 35 Removing Fan and Clutch Assembly

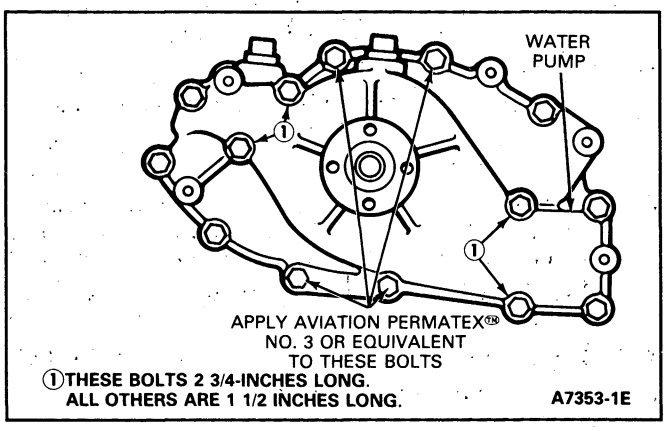


FIG. 36 Water Pump

8. Install power steering pump and drive belt.
9. Install A/C compressor bracket and tighten to specification.
10. Install A/C compressor and drive belt.
11. Install alternator adjusting arm and alternator drive belt.
12. Install vacuum pump drive belt.
13. Adjust accessory drive belts to specification. Refer to Section 27-06, Accessory Drive Belt Service.
14. Install fan and clutch assembly using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B or equivalent, and tighten to specification.

    CAUTION: LH thread. Turn nut counter-clockwise to tighten.

15. Install radiator fan shroud halves. Refer to Section 27-04, Radiators.
16. Fill and bleed cooling system. Refer to Section 27-02, Cooling System Service.
17. Connect ground cables to both batteries.
18. Run engine and check for coolant leaks.

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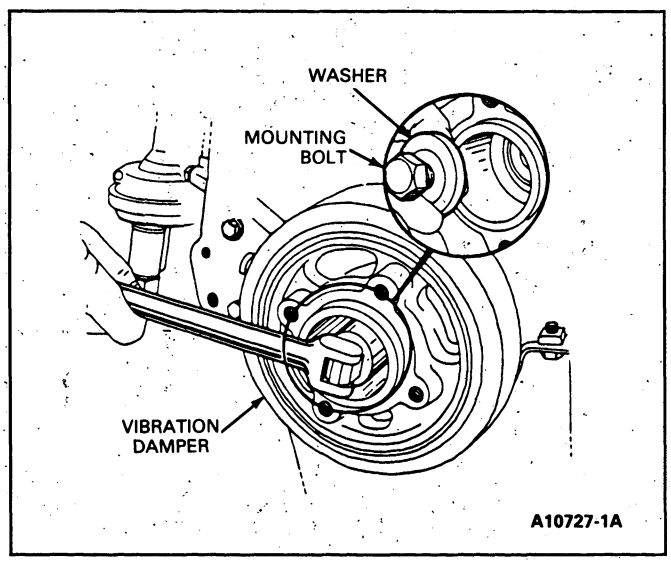


FIG. 37 Crankshaft Damper Removal

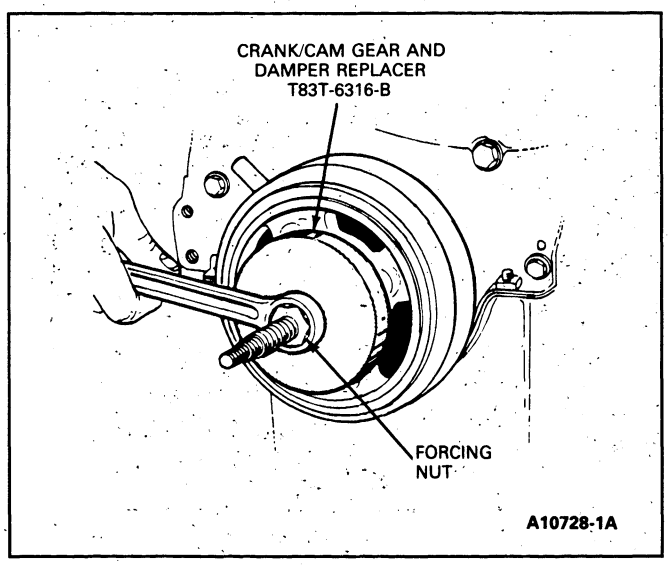


FIG. 38 Crankshaft Damper Installation

Crankshaft Vibration Damper

Removal

1. Disconnect ground cables from both batteries.
2. Remove radiator fan shroud. Refer to Section 27-04, Radiators.
3. Remove fan and clutch assembly as outlined using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B or equivalent.

   CAUTION: LH thread. Remove by turning nut clockwise.
4. Loosen and remove A/C compressor drive belt.
5. Loosen and remove power steering pump drive belt.
6. Loosen and remove alternator and vacuum pump drive belts.
7. Raise vehicle.
8. Remove crankshaft pulley.
9. Remove bolt attaching damper to crankshaft.
10. Install Crank/Cam Gear and Damper Remover T83T-6316-A or equivalent, and remove crankshaft damper (Fig. 37).

    NOTE: To prevent crankshaft rotation, use breaker bar for in vehicle removal, or Flywheel Holding Tool T74P-6375-A or equivalent, for bench overhaul.

Installation

NOTE: A new front crankshaft seal should be installed whenever the crankshaft damper is removed.

1. Lubricate the damper seal nose with clean engine oil, and install using Crank/Cam Gear and Damper Replacer T83T-6316-B or equivalent, (Fig. 38).

   NOTE: Add Silicone Rubber Sealant D6AZ-19562-A, or equivalent to engine side of washer (in area of keyway only), to prevent oil leakage past keyway.
2. Install bolt attaching damper to crankshaft and tighten to specification.
3. Install crankshaft pulley and tighten to specification.
4. Lower vehicle.
5. Install alternator, vacuum pump, power steering pump, and A/C compressor drive belts. Adjust to specification. Refer to Section 27-06, Accessory Drive Belt Service.
6. Install fan and clutch assembly using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B or equivalent.

   CAUTION: LH thread. Turn nut counterclockwise to tighten.

   Tighten nut to specifications.
7. Install radiator fan shroud. Refer to Section 27-04, Radiators.
8. Connect ground cables to both batteries.

Front Crankshaft Oil Seal

In-Vehicle Replacement

Use The Following Procedure

Removal

1. Disconnect battery ground cables from both batteries.
2. Remove radiator fan shroud. Refer to Section 27-04, Radiators.
3. Remove fan and clutch assembly as outlined using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B or equivalent.

   CAUTION: LH thread. Remove by turning nut clockwise.
4. Loosen and remove A/C compressor drive belt.
5. Loosen and remove power steering pump drive belt.
6. Loosen and remove alternator and vacuum pump drive belts.
7. Raise vehicle.
8. Remove crankshaft pulley.
9. Remove bolt attaching damper to crankshaft.
10. Install Crank/Cam Gear and Damper Remover T83T-6316-A, or equivalent, and remove

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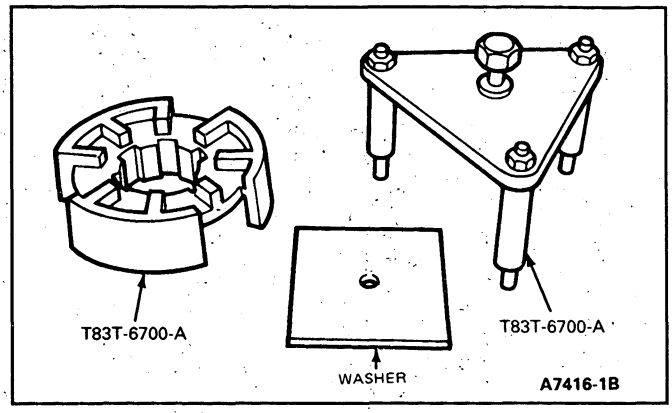


FIG. 39 Front Crank Seal Replacer-T83T-6316-A—In Vehicle

crankshaft vibration damper. To prevent crankshaft rotation install breaker bar into removal tool.

11. Pry out front oil seal from the front cover using a screwdriver.

    CAUTION: Use care to prevent damage to the front cover, crankshaft or breaking oil pan seal by bending front cover.

Installation

1. Coat new oil seal with Multi-Purpose grease D0AZ-19584-AA or equivalent.

   NOTE: It may be necessary to rotate crankshaft to align the damper key with seal installing tool (Fig. 39).

2. For engines without three weldnuts on front cover, place seal into Front Crank Seal Replacer T83T-6700-A or equivalent, and install over end of crankshaft. Install Crank/Cam Gear and Damper Replacer T83T-6316-B or equivalent, and tighten nut against washer and installation tool to force seal into front cover plate (Fig. 40).

   CAUTION: Use care to prevent bending front cover during oil seal installation and breaking oil pan seal.

3. For engines with three weldnuts on front cover, place seal into Front Crank Seal Replacer T83T-6700-A or equivalent, install over end of crankshaft and attach bridge to weldnuts. Draw seal into front cover by rotating center screw clockwise (Fig. 40).

   NOTE: Seal is automatically installed at the proper depth when the tool bottoms on the front cover.

4. Clean grease from outside surfaces and apply a 3.2mm (1/8 inch) bead of Silicone Rubber Sealant D6AZ-19562-A or equivalent, around the outside diameter of the front seal and the edge of the front cover.

   NOTE: When applying RTV rubber silicone sealant, always use the bead size specified and join the components within 15 minutes of application. After this amount of time the sealant begins to "set-up" and its sealing effectiveness may be reduced.

5. Lubricate the damper seal nose with clean engine oil and install crankshaft vibration damper using Crank/Cam Gear and Damper Replacer T83T-6316-B or equivalent.

6. Add Silicone Rubber Sealant D6AZ-19562-A or equivalent, to engine side of washer (in area of keyway only), to prevent oil leakage past keyway. Install bolt attaching vibration damper to crankshaft and tighten to specification.

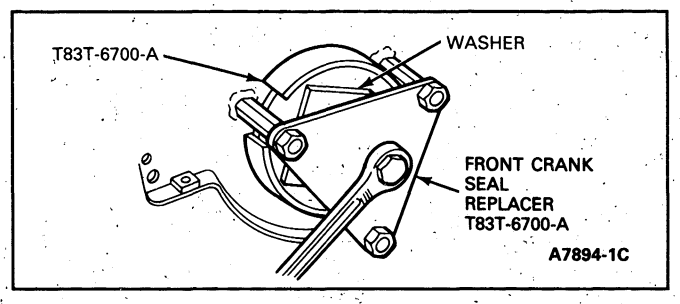


FIG. 40 Front Crankshaft Seal Installation—In Vehicle

7. Install crankshaft pulley and tighten to specification.
8. Lower vehicle.
9. Install alternator, vacuum pump, power steering pump, and A/C compressor drive belts. Adjust to specification. Refer to Section 27-06, Accessory Drive Belt Service.
10. Install fan and clutch assembly using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B or equivalent.

    CAUTION: LH thread. Turn nut counterclockwise to tighten. Tighten nut to specifications.

11. Install radiator fan shroud halves. Refer to Section 27-04, Radiators.
12. Connect ground cables to both batteries.

Engine Front Cover and Crankshaft Oil Seal

Bench Procedure-Use The Following Procedure

Removal

1. Disconnect ground cables from both batteries.
2. Drain cooling system.
3. Remove air cleaner and install intake air opening cap Intake Manifold Cover T83T-9424-A or equivalent.
4. Remove radiator fan shroud. Refer to Section 27-04, Radiators.
5. Remove fan and clutch assembly using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B or equivalent.

   CAUTION: LH thread. Remove by turning nut clockwise.

6. Remove injection pump, as outlined.
7. Remove injection pump adapter, as outlined.
8. Remove water pump, as outlined.
9. Raise vehicle.
10. Remove crankshaft pulley and vibration damper, as outlined.
11. Remove ground cables at front of engine.
12. Remove five bolts attaching front cover to engine block and oil pan.
13. Lower vehicle.
14. Remove bolts attaching engine front cover to engine block, and remove front cover.

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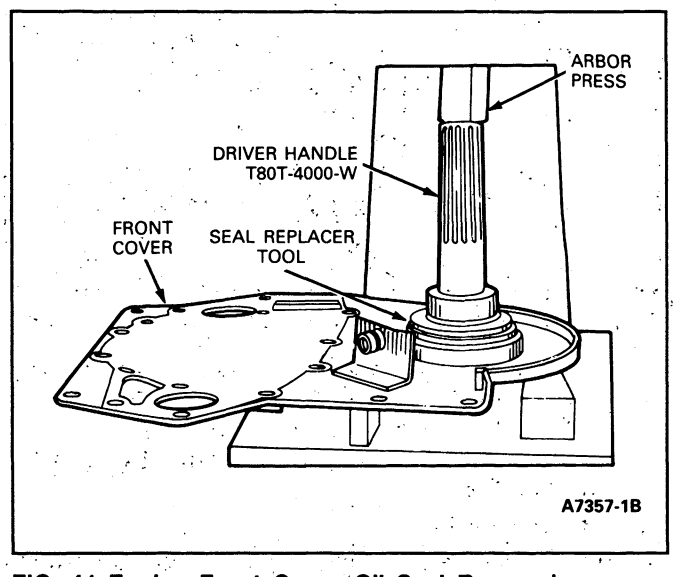


FIG. 41 Engine Front Cover Oil Seal Removal

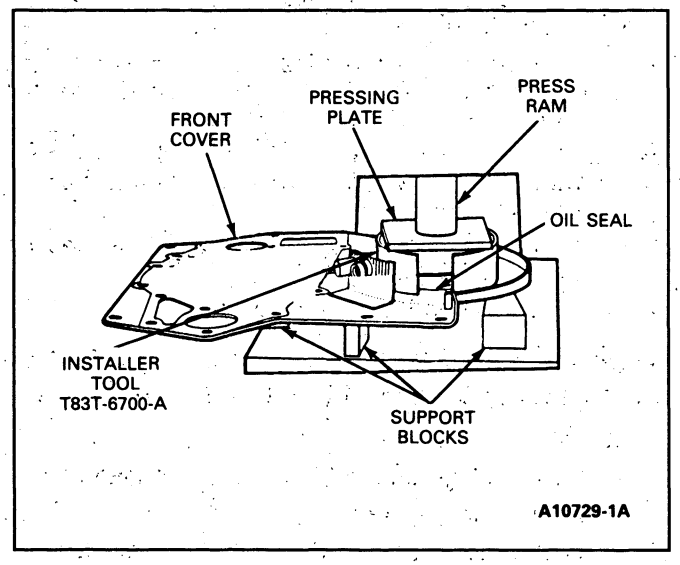


FIG. 42 Engine Front Cover Oil Seal Installation

15. Support engine front cover, and using an arbor press, Drive Handle T80T-4000-W or equivalent, and an 82.55mm (3 1/4 inch) diameter spacer, drive crankshaft seal out of front cover (Fig. 41).

Installation

1. Remove old gasket material and clean engine block, engine front cover, and oil pan sealing surfaces with a suitable solvent and dry thoroughly.
2. Clean water pump sealing surface.
3. Coat new front crankshaft oil seal with Multi-Purpose grease D0AZ-19584-AA or equivalent.
4. Install new oil seal using Front Crank Seal Replacer T83T-6700-A or equivalent, a suitable spacer, and an arbor press.

   CAUTION: Support engine front cover (Fig. 37).

   Bottom out tool on front cover surface. Seal is automatically installed at proper depth (Fig. 42).
5. Clean outside surfaces of the front cover to remove any grease and apply a 3.2mm (1/8 inch) bead of Silicone Rubber Sealant D6AZ-19562-A or equivalent, around the outside diameter of the front seal and the edge of the front cover.

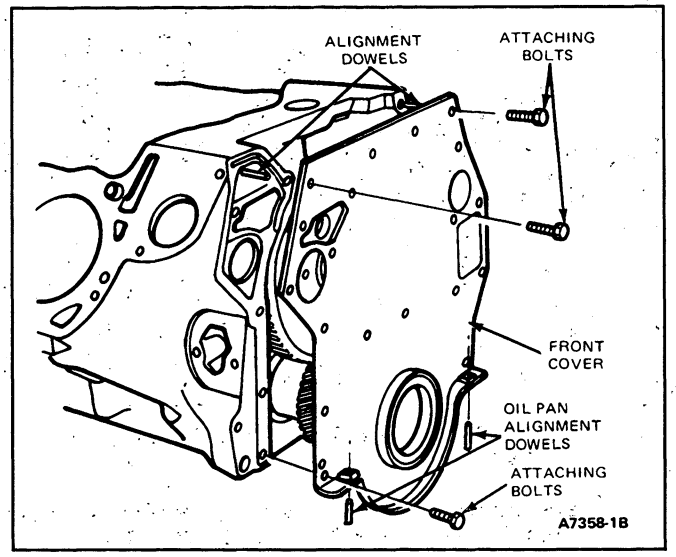


FIG. 43 Front Cover Alignment Dowels

6. For in-vehicle repair, install fabricated alignment dowels, (Fig. 43) on engine block and oil pan to align front cover and gaskets. For overhaul repair, install fabricated alignment dowels as shown in Fig. 35.
7. Silicone Rubber Sealant D6AZ-19562-A or equivalent on engine block and front cover sealing surfaces.
8. Install gaskets on engine block.

   NOTE: Silicone Rubber Sealant should be applied immediately prior to front cover installation. When applying Silicone Rubber Sealant, always use the bead size specified and join the components within 15 minutes of application. After 15 minutes the sealant begins to "set-up" and sealing effectiveness may be reduced.
9. For in vehicle repair, apply a 3.2mm (1/8-inch) bead of Silicone Rubber D6AZ-19562-A, or equivalent, to rear corners of oil pan and apply a 6.4mm (1/4 inch) bead of Silicone Rubber D6AZ-19562-A, or equivalent on oil pan as shown in Fig. 44.
10. Install engine front cover in position, on oil pan dowels first, and install three attaching bolts as shown in Fig. 43.
11. For in-vehicle repair, remove engine front cover alignment dowels from engine and oil pan. Install and hand tighten remaining front cover bolts.
12. Install fabricated alignment dowels in engine block, (Fig. 35), if necessary.
13. Install water pump gasket on engine front cover alignment dowels.
14. Install water pump and hand tighten bolts.

    NOTE: Apply Silicone Rubber Sealant D6AZ-19562-A, or equivalent to four bolts as shown in Fig. 36.
15. Remove alignment dowels and install two remaining attaching bolts.

    Tighten all water pump bolts to specification.

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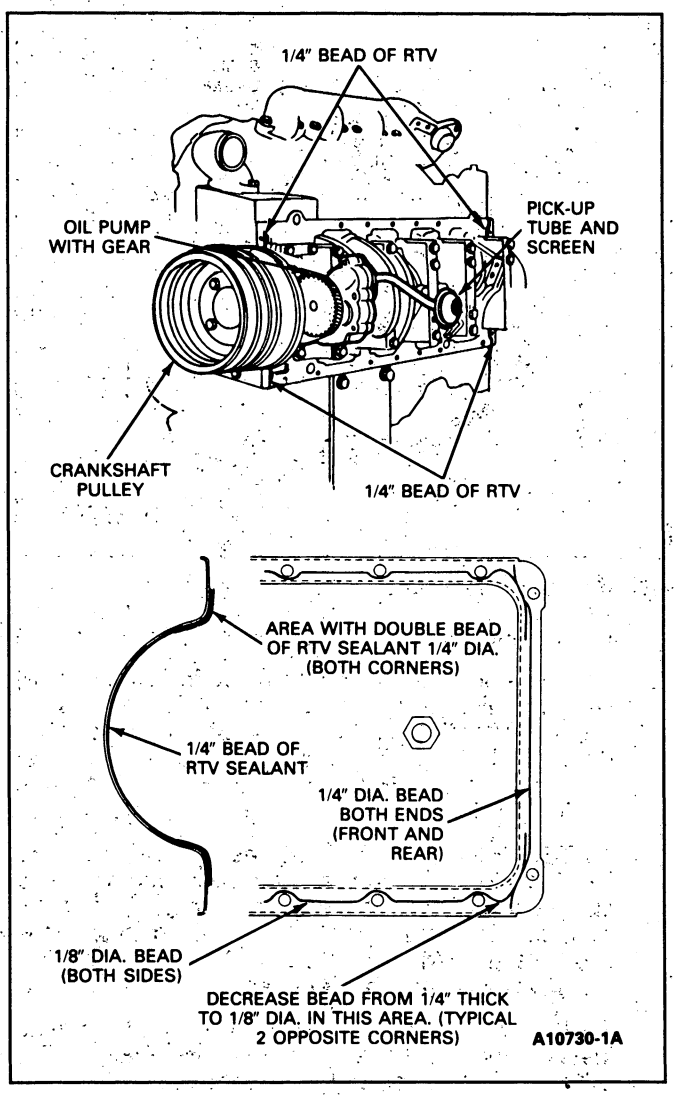


FIG. 44 Front Cover RTV Sealant

16. Tighten engine front cover bolts to specification.
17. Install injection pump adapter, as outlined.
18. Install injection pump, as outlined.
19. Install heater hose fitting in pump using Pipe Sealant With Teflon® D8AZ-19554-A, or equivalent.
20. Connect heater hose to water pump and tighten clamp to specification.
21. Raise vehicle.
22. Lubricate damper seal nose with clean engine oil and install crankshaft vibration damper, using Crank/Cam Gear and Damper Replacer T83T-6316-B or equivalent, (Fig. 38).

    NOTE: Add Silicone Rubber Sealant D6AZ-19562-A, to engine side of retaining bolt washer to prevent oil leakage past keyway.
23. Install vibration damper-to-crankshaft attaching bolt and tighten to specification.
24. Install crankshaft pulley and tighten to specification.
25. Install both battery ground cables on front of engine.
26. Lower vehicle.

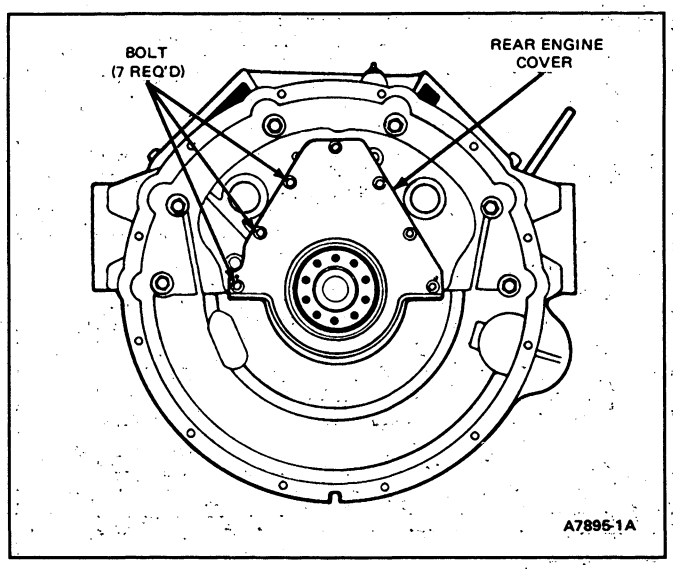


FIG. 45 Rear Engine Cover Removal

27. Install alternator adjusting arm bracket and tighten to specification.
28. Install water pump pulley and tighten to specification.
29. Install power steering pump bracket and tighten to specification.
30. Install power steering pump and drive belt.
31. Install A/C compressor bracket and tighten to specification.
32. Install A/C compressor and drive belt.
33. Install alternator adjusting arm and install alternator and vacuum pump drive belts.
34. Adjust alternator, vacuum pump, power steering pump and A/C compressor drive belts to specification. Refer to Section 27-06, Accessory Drive Belt Service.
35. Install fan and clutch assemble using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B or equivalents.
36. Install radiator fan shroud halves. Refer to Section 27-04, Radiators.
37. Remove intake manifold cover. Install air cleaner and tighten to specification.
38. Connect ground cables to both batteries.
39. Fill and bleed cooling system. Refer to Section 27-02, Cooling System Service.
40. Operate engine and inspect for coolant and oil leaks.

Flywheel, Engine Rear Cover and Oil Seal

Removal

1. Remove transmission and integral clutch housing (manual transmission). Refer to Group 16 or Group 17, in Body/Chassis/Electrical Manual.
2. Remove clutch and clutch housing, if so equipped. Refer to Group 16, in Body/Chassis/Electrical Manual.
3. Remove nine flywheel mounting bolts and spacer and remove flywheel (Fig. 18).

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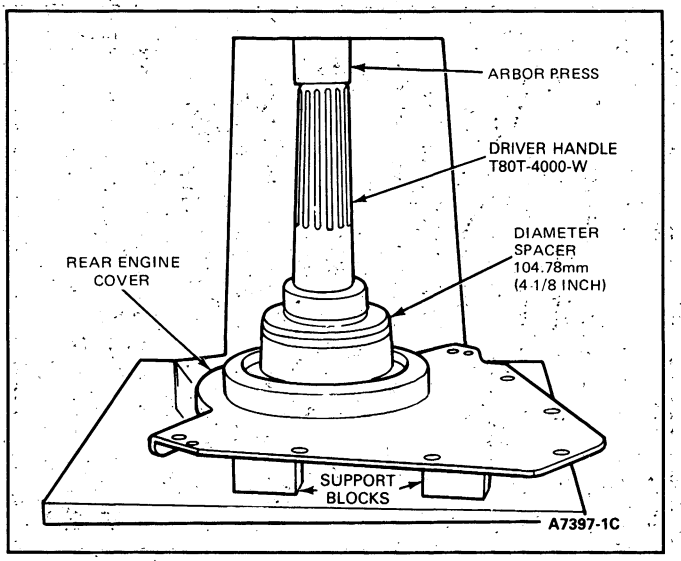


FIG. 46 Rear Oil Seal Removal and Installation

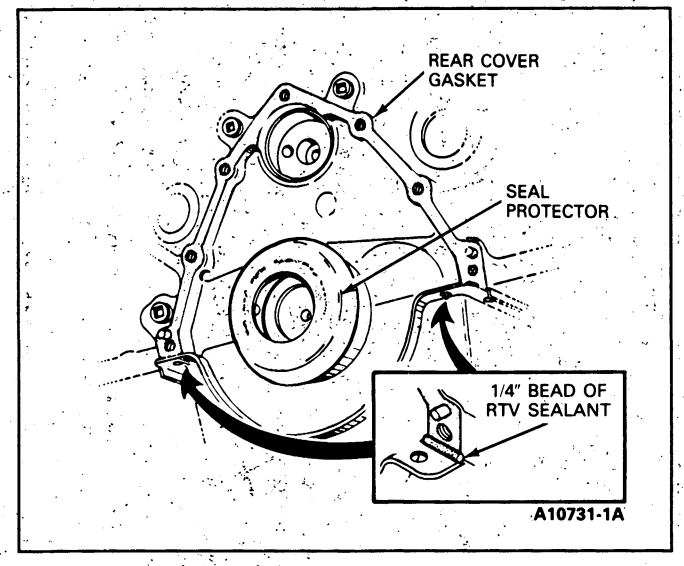


FIG. 47 Rear Cover Gasket Installation

4. Remove bolts attaching rear engine cover to engine block and remove rear cover (Fig. 45).
5. Using an arbor press and a suitable spacer 104.78mm (4 1/8-inch) diameter, remove rear oil seal.

   NOTE: Support rear cover (Fig. 46).

   NOTE: If rear cover seal fails repeatedly, check rear cover bore concentricity as follows:

   - Install rear cover to engine with oil seal removed.
   - Mount a dial indicator (on swivel joint) onto the crankshaft flange. Position the dial indicator press against the I.D. of the rear cover seal bore.
   - Measure at four equal spaced locations.
   - Rear cover seal bore will be connected to the crankshaft centerline in accordance with Specifications.
   - Replace rear cover if not within specifications.

Installation

1. Clean rear cover and engine block gasket surfaces.
2. Remove old RTV sealant from oil pan to rear cover sealing surface on oil pan. Clean sealing surfaces with a suitable solvent, and dry thoroughly.
3. Coat rear engine cover seal bore I.D. with Gasket and Seal Contact Adhesive, D7AZ-19B508-A or equivalent. Using an arbor press and Rear Crankshaft Seal Replacer T83T-6701-A or equivalent, install new rear main oil seal.

   NOTE: Seal must be installed from the engine block side of rear cover flush with seal bore inner surface.
4. Apply a 3.2mm (1/8 inch) bead of Silicone Rubber Sealant D6AZ-19562-A or equivalent around the outside diameter of the rear seal and the edge of the rear cover.
5. Install Rear Crankshaft Seal Pilot T83T-6701-B or equivalent, onto crankshaft.
6. Apply Gasket and Seal Contact Adhesive D7AZ-19B508-A, or equivalent, to engine block and rear cover gasket surfaces.
7. Install rear cover gasket to engine block (Fig. 47).
8. For in-vehicle repair, apply a 6.35mm (1/4 inch) bead of Silicone Rubber Sealant D6AZ-19562-A or equivalent at the corners or the oil pan and apply a 6.35mm (1/4 inch) bead of Silicone Rubber Sealant D6AZ-19562-A or equivalent, on oil pan sealing surface.

   NOTE: When applying Silicone Rubber Sealant, D6AZ-19562-A or equivalent, always use the bead size specified and join the components within 15 minutes of application. After 15 minutes the sealant begins to "set-up", and sealing effectiveness may be reduced.
9. Push rear cover into position on engine block and install attaching bolts. Remove Seal Pilot, T83T-6701-B. Tighten all bolts to specification.
10. Position flywheel on crankshaft flange. Coat threads of flywheel attaching bolts with Perfect Seal Sealing Compound B5A-19554-A, or equivalent, and install spacer, bolts and washers (with flexplate, if so equipped). Tighten bolts to specification, alternating across from each other.
11. Install clutch, if so equipped. Refer to Group 16, in Body/Chassis/Electrical Manual.
12. Install transmission. Refer to Group 16 or Group 17 in Body/Chassis/Electrical Manual.
13. Run engine and check for oil leaks.

Secondary Flywheel

Removal

NOTE: The secondary flywheel inertia mass contains the clutch friction surface. Excessive clutch slipping can result in warpage or other surface distress which requires refacing or replacement of the secondary flywheel. Refer to Inspection and Repair in this Section. The back side of the secondary flywheel contains a friction surface which is used in the internal torque limitation system of the Dual Mass Flywheel assembly.

1. Remove the transmission, clutch pressure plate, and disc as outlined in Group 16 of the Body/Chassis/Electrical Manual.

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2. Remove six bolts retaining the secondary flywheel to the primary flywheel assembly (Fig 18). Do not permit the flywheel to fall from the vehicle.
3. Using a screwdriver or other suitable tool, pry the secondary flywheel off of its mounting pilot. Use care when removing the flywheel to prevent dropping.

Installation

1. Clean the clutch friction surface and torque limitation friction surface with a suitable commercial alcohol base solvent to be sure that surfaces are free from any oil film.
2. Position secondary flywheel onto its mounting pilot on the primary flywheel assembly and align the six secondary flywheel attaching bolt holes with the six threaded holes of the primary flywheel assembly.
3. Coat threads of secondary flywheel attaching bolts with Ford Threadlock and Sealer EDAZ-19554-B or equivalent, and install bolts. Tighten bolts to specification, alternating across from each other.

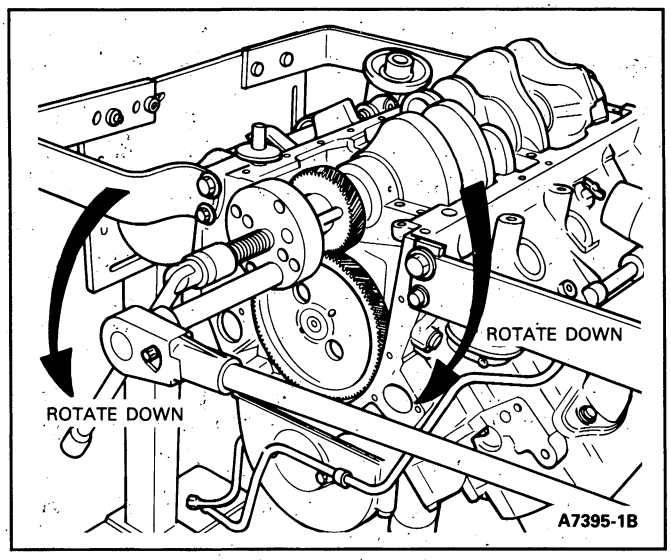


FIG. 48 Crankshaft Drive Gear Removal

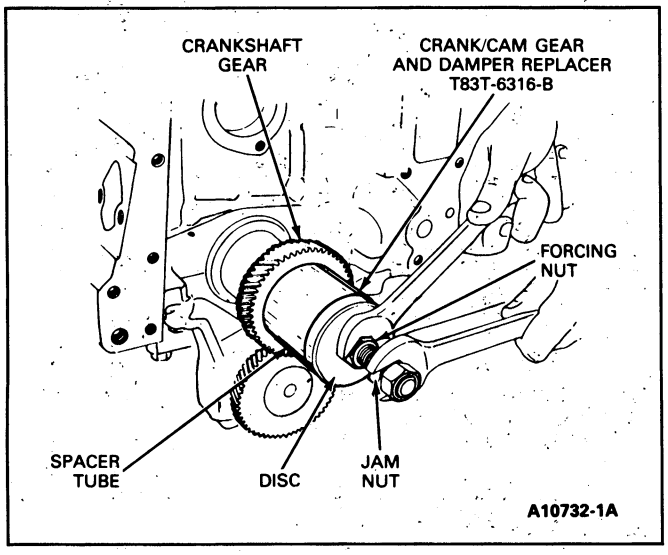


FIG. 49 Crankshaft Drive Gear Installation

4. Install the clutch pressure plate, disc, and transmission as outlined in Group 16 of the Body/Chassis/Electrical Manual.

Flywheel Ring Gear

Removal

1. Remove transmission. Refer to Group 16 in the Body/Chassis/Electrical Manual.
2. Remove the clutch housing. Refer to Group 16 in the Body/Chassis/Electrical Manual.
3. Remove flywheel as outlined.
4. To replace a damaged or worn ring gear (Fig. 18), heat the ring gear with a blow torch on the engine side of the gear, and knock it off the flywheel. **Do not hit the flywheel when removing the ring gear.**

Installation

1. Heat the new ring gear evenly until the gear expands enough to slip onto the flywheel. Make sure the gear is seated properly against the shoulder. **Do not heat any portion of the gear to a temperature higher than 278°C (500°F). If this limit is exceeded, the hardness will be removed from the ring gear teeth.**
2. Install flywheel as outlined.
3. Install clutch housing and transmission. Refer to Group 16 in the Body/Chassis/Electrical Manual.

Crankshaft Drive Gear

Removal

1. Disconnect ground cables from both batteries.
2. Remove air filter and install Intake Manifold Cover T83T-9424-A or equivalent, on intake manifold opening.
3. Drain cooling system.
4. Remove radiator fan shroud. Refer to Section 27-04, Radiators, in this Manual.
5. Remove fan and clutch assembly using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B or equivalent.

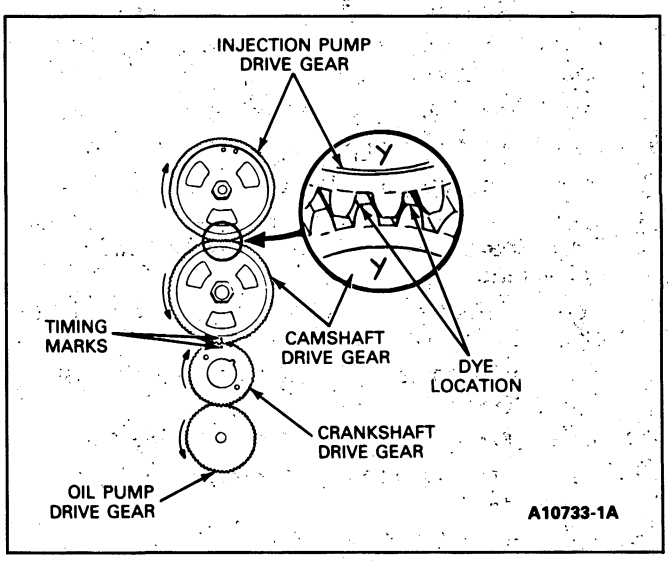


FIG. 50 Aligning Timing Marks

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NOTE: LH thread. Turn nut clockwise to remove.

6. Loosen and remove alternator and vacuum pump belts.
7. Remove A/C compressor and position out of the way.
8. Remove A/C mounting bracket.
9. Remove power steering pump and position out of the way.
10. Remove power steering pump bracket.
11. Remove water pump pulley.
12. Remove water pump, as outlined.
13. Remove engine front cover, as outlined.
14. Install Crank/Cam Gear and Damper Remover T83T-6316-A or equivalent, and using a breaker bar (in-vehicle procedure) to prevent crankshaft rotation, or Flywheel Holding T74P-6375-A (bench procedure) or equivalent, remove crankshaft gear (Fig. 48).

Installation

1. Install crankshaft gear using Crank/Cam Gear and Damper Replacer T83T-6316-B or equivalent, (Fig. 45) aligning crankshaft drive gear timing mark with crankshaft drive gear timing mark (Fig. 50).

   NOTE: Gear may be heated to 149-177°C (300-350°F) for ease of installation. Heat in oven. Do not use torch.
2. Clean engine front cover, water pump and engine block sealing surface with a suitable solvent and dry thoroughly.
3. Install new crankshaft oil seal into engine front cover, as outlined.
4. Install engine front cover, as outlined.
5. Install crankshaft vibration damper using Crank/Cam Gear and Damper Replacer T83T-6316-B or equivalent, (Fig. 38).

   NOTE: Apply Silicone Rubber Sealant D6AZ-19562-A or equivalent, to engine side of washer (in area of keyway only), to prevent oil leakage past Keyway.
6. Install crankshaft vibration damper attaching bolt and tighten to specification.
7. Install crankshaft pulley and tighten to specification.
8. Install water pump as outlined (Fig. 36).
9. Install injection pump adapter, as outlined.
10. Install injection pump as outlined.
11. Install heater hose fitting into water pump using Pipe Sealant With Teflon® D8AZ-19554-A, or equivalent.
12. Connect heater hose to water pump and tighten clamp to specification.
13. Install power steering pump bracket and tighten to specification.
14. Install power steering pump and drive belt
15. Install A/C compressor bracket and tighten to specification.
16. Install A/C compressor and drive belt.
17. Install alternator adjusting arm. Install alternator, vacuum pump and drive belts.
18. Adjust alternator, vacuum pump, power steering pump, and A/C compressor drive belts to specification. Refer to Section 27-06, Accessory Drive Belt Service.
19. Refer to Engine/Emissions Diagnosis Manual* for injection pump timing procedure.
20. Install radiator fan and clutch assembly using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B or equivalents. Tighten to specification.
21. Install radiator fan shroud halves. Refer to Section 27-04, Radiators.
22. Fill and bleed cooling system. Refer to Section 27-02, Cooling System Service.
23. Remove intake manifold cover. Install aircleaner and tighten to specification.
24. Connect ground cables to both batteries.
25. Operate engine and inspect for oil and coolant leaks.

Injection Pump Drive Gear and Gear Cover

Removal

1. Disconnect ground cables from both batteries.
2. Remove engine cover (E-250—E-350 only).
3. Remove air cleaner and install intake opening cover, Intake Manifold Cover T83T-9424-A or equivalent.
4. Remove injection pump, as described in this Section.
5. Remove bolts attaching injection pump drive gear cover to engine block, and remove cover (Fig. 51).

   NOTE: Do not remove drive gear yet.
6. Turn engine over by hand to TDC (compression stroke) of No. 1 piston.

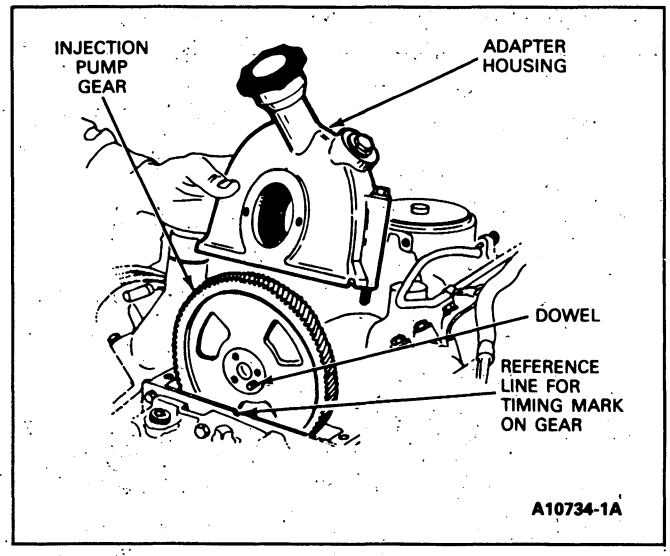


FIG. 51 Drive Gear Cover

*Can be purchased as a separate item.

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NOTE: Remove glow plugs with Glow Plug Socket D83T-6002-A or equivalent, to facilitate turning engine over by hand.

NOTE: To determine that No. 1 piston is at TDC (compression stroke), position injection pump drive gear dowel at four o'clock position. The scribe line in vibration damper should be at TDC.

NOTE: To aid aligning the timing marks, the pump drive gear and the camshaft gear are marked with "Y" timing marks. The crankshaft and camshaft gears are marked with "o" (dot) alignment marks (Fig. 45). With engine at TDC Compression for No. 1 cylinder, the "Y" marks should be aligned.

7. Slide injection pump gear back (do not remove) to expose top of camshaft gear when looking down into the front cover. In addition to the "Y", the gear teeth adjacent to the "Y" on the camshaft gear are permanently dyed.

CAUTION: Do not remove injection pump gear without following this procedure.

8. Remove injection pump drive gear.

Installation

1. Clean all gasket and sealing surfaces with a suitable solvent and dry thoroughly.

NOTE: To determine that No. 1 piston is at TDC of compression stroke, position injection pump drive gear dowel at four o'clock position. The scribe line in vibration damper should be at TDC.

2. With drawn line on drive gear at six o'clock position, install gear and align all drive gear timing marks.

CAUTION: Use extreme care to avoid disturbing injection pump drive gear, once it is in position.

3. Apply a 3.16mm (1/8 inch) bead of Silicone Rubber Sealant D6AZ-19562-A or equivalent, along bottom surface of injection pump drive gear cover.

NOTE: When applying Silicone Rubber Sealant, D6AZ-19562-A or equivalent, always use the bead size specified and join the components within 15 minutes of application. After 15 minutes, sealant begins to "set-up", and sealing effectiveness may be reduced.

4. Install injection pump drive gear cover and tighten retaining bolts to 19 N·m (14 ft-lb). Apply Perfect Seal Sealing Compound B5A-19554-A or equivalent, to bolt threads before assembly.

NOTE: With injection pump drive gear cover installed, the injection pump drive gear cannot "jump" timing.

5. Remove intake manifold cover. Install air cleaner and tighten to specification.
6. Install ground cables to both batteries.
7. Run engine and check for oil, fuel and coolant leaks.
8. If necessary, purge high-pressure fuel lines of air by loosening connector one-half to one turn and cranking engine until bubble-free fuel flows from connection.

CAUTION: Keep eyes and hands away from nozzle spray. Fuel spraying from the nozzle under high pressure can penetrate the skin and cause infection. Medical attention should be provided immediately in the event of skin penetration.

9. Install engine cover (E-250—E-350).

Camshaft Drive Gear, Fuel Pump Cam, Spacer and Thrust Plate

Removal

1. Disconnect ground cables from both batteries.
2. Remove air cleaner and install Intake Manifold Cover T83T-9424-A or equivalent, on intake manifold opening.
3. Drain cooling system. Refer to Section 27-02, Cooling System Service.
4. Loosen and remove alternator and vacuum pump drive belts.
5. Remove A/C compressor mounting bolts and position compressor out of the way.
6. Remove A/C compressor mounting bracket.
7. Remove power steering pump and position out of the way.

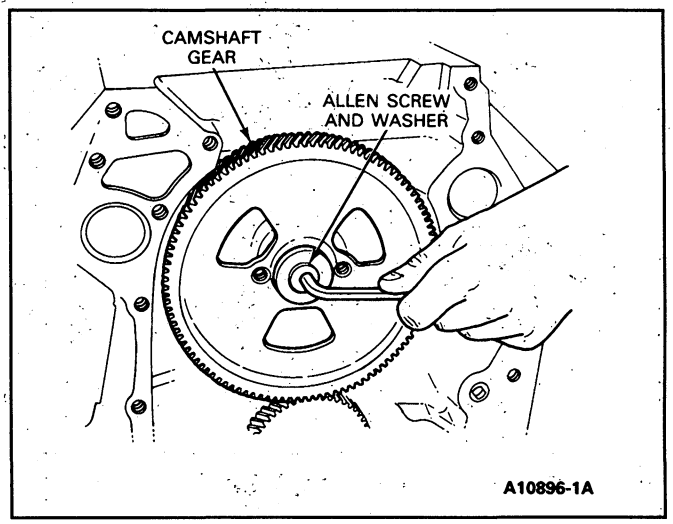


FIG. 52 Camshaft Drive Gear Allen Screw

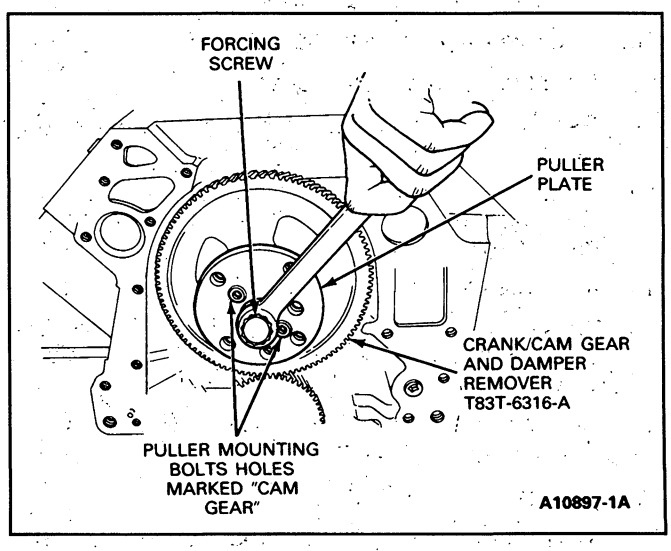


FIG. 53 Camshaft Drive Gear Removal

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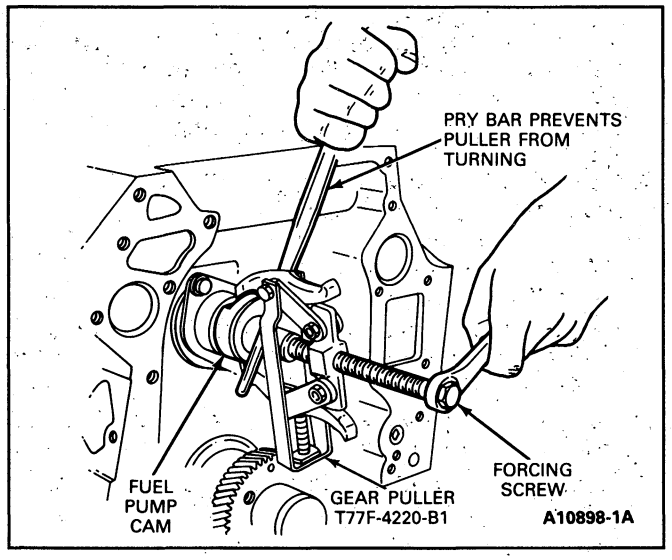


FIG. 54 Removing Fuel Pump Cam

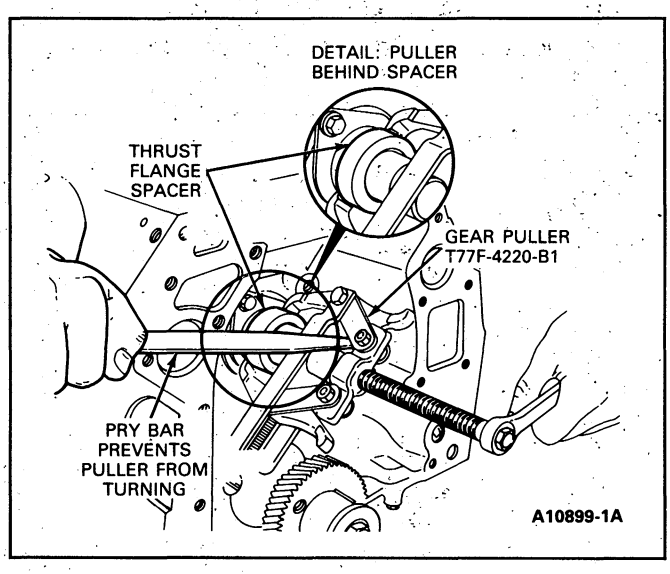


FIG. 55 Removing Thrust Flange Spacer

8. Remove power steering pump bracket.
9. Remove water pump pulley.
10. Remove water pump, as outlined.
11. Remove engine front cover, as outlined.
12. Remove camshaft allen screw and washer (Fig. 52).
13. Install gear puller, using Crank/Cam Gear and Damper Remover T83T-6316-A or equivalent and remove gear (Fig. 53).
14. If necessary, remove fuel supply pump as outlined.
15. Install Gear Puller T77F-4220-B1 or equivalent, and remove fuel pump cam and thrust flange spacer, if necessary (Figs. 54 and 55).
16. Remove bolts attaching thrust plate, and remove thrust plate, if necessary.

Installation

1. Install new thrust plate, if removed, and tighten to specification.

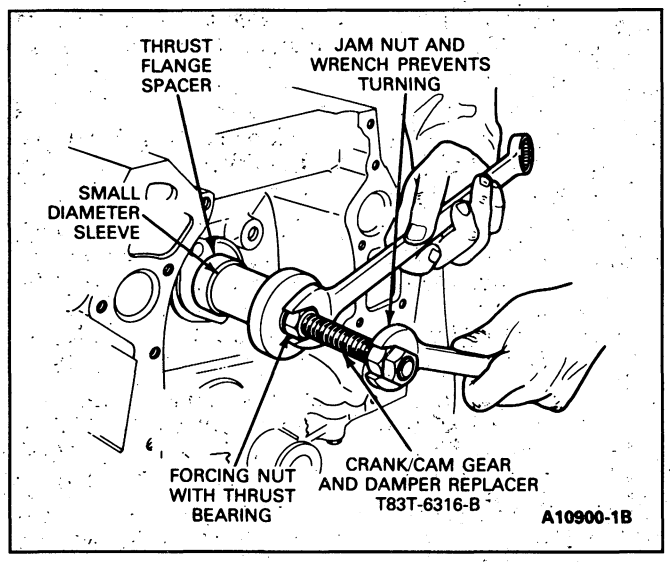


FIG. 56 Installing Thrust Flange Spacer

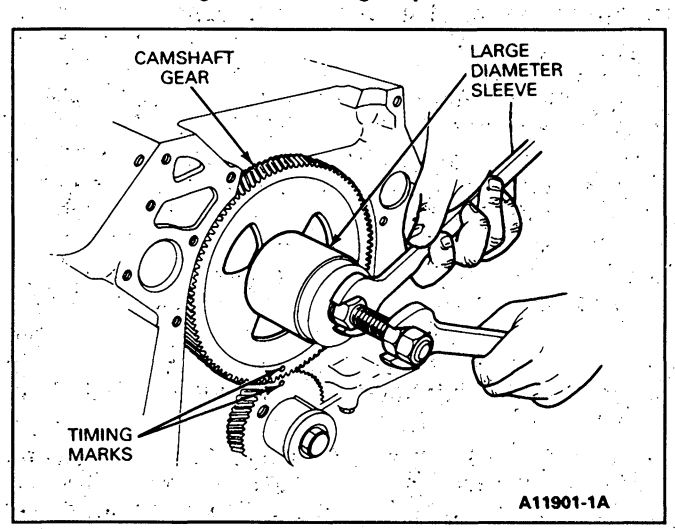


FIG. 57 Installing Camshaft Gear

NOTE: Replace fuel pump cam if nicked, scored, or otherwise damaged. If fuel pump cam is replaced, replace fuel pump.

2. Install spacer and fuel pump cam against camshaft thrust flange, using Crank/Cam Gear and Damper Replacer T83T-6316-B or equivalent, if removed (Fig. 56).
3. Install camshaft drive gear against fuel pump cam, aligning timing mark with mark on crankshaft drive gear, using Crank/Cam Gear and Damper Replacer T83T-6316-B or equivalent (Fig. 57).
4. Install camshaft allen screw and tighten to specification.
5. Install fuel pump as outlined.
6. Install new crankshaft oil seal in engine front cover, as outlined.
7. Install engine front cover, as outlined.
8. Install water pump, as outlined.
9. Install injection pump gear and adapter, as outlined.
10. Install injection pump, as outlined.
11. Install water pump pulley.

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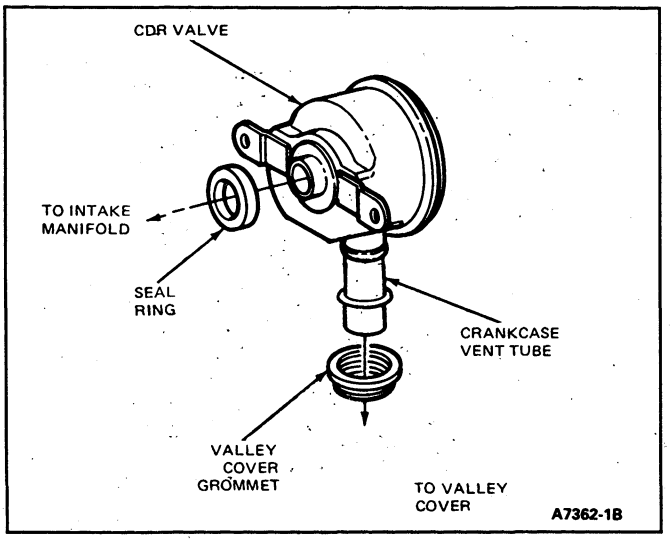


FIG. 58 CDR Installation

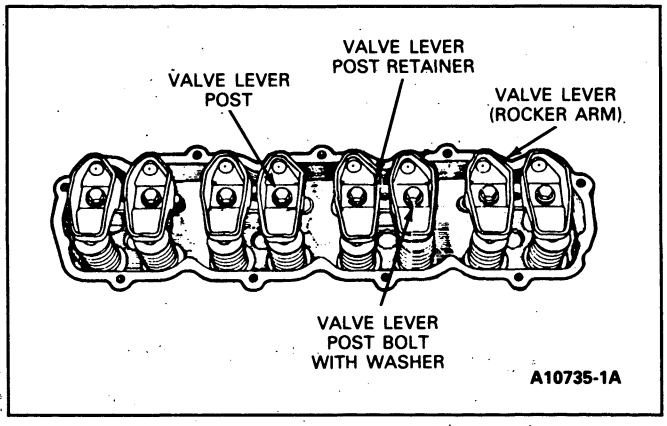


FIG. 59 Valve Rocker Arm Assembly

12. Install power steering pump bracket and tighten to specifications.
13. Install power steering pump and drive belt.
14. Install A/C compressor mounting bracket. Tighten mounting bracket bolts to specification.
15. Install A/C compressor and drive belt.
16. Install alternator and vacuum pump drive belts.
17. Adjust alternator, vacuum pump, A/C compressor and power steering pump drive belts to specifications. Refer to Section 27-06, Accessory Drive Belt Service.
18. Connect ground cables to both batteries.
19. Remove intake manifold cover and install air cleaner and tighten to specification.
20. Run engine and check for fuel, oil, and coolant leaks.
21. If necessary, purge high pressure fuel pipes of air by loosening connector one half to one turn and cranking engine until bubble-free fuel flows from connection.

CAUTION: Keep eyes and hands away from nozzle spray. Fuel spraying from the nozzle under high pressure can penetrate the skin and cause infection. Medical attention should be provided immediately in the event of skin penetration.

Crankcase Depression Regulator (CDR)

Removal

1. Open hood on F-250—F-350. Remove engine cover on E-250—E-350.
2. Remove air cleaner and install Intake Manifold Cover T83T-9424-A or equivalent, onto intake manifold opening.
3. Remove two bolts attaching CDR valve to intake manifold and remove valve.

Installation

1. Install new seal ring, backup ring and O-rings onto CDR valve and install valve into crankcase vent tube (Fig. 50).
2. Install two CDR valve attaching bolts into intake manifold and tighten to specification.
3. Install air cleaner and tighten to specification.
4. Close hood or install engine cover as required.

Valve Cover, Rocker Arm, and Push Rod

Removal

1. Disconnect ground cables from both batteries.
2. On E-250—E-350, remove fan shroud. Refer to Section 27-04, Radiators.
3. Remove engine cover (E-250—E-350 only).
4. Perform steps 4 through 9 on E-250—E-350, RH side only: Remove engine oil dipstick tube fasteners and remove dipstick, tube assembly and valve cover bracket.
5. Remove transmission filler tube fasteners and remove filler tube and dipstick.
6. Raise vehicle.
7. Remove nuts attaching RH engine mount insulator to frame.
8. Slightly raise RH side of the engine until fuel filter header touches vehicle sheet metal. Install suitable wood block between insulator and frame. Lower engine on block.
9. Lower vehicle.
10. Remove valve cover attaching screws and remove covers.
11. Remove valve rocker arm post mounting bolts (Fig. 59).
12. Remove valve rocker arms and posts in order and identify so they are returned to their original positions.

NOTE: It is not necessary to disassemble the rocker arms from their pedestal assemblies to inspect them. Inspect rocker arms by rotating to the maximum position and view the post area from the underside (Fig. 60).

13. Remove push rods in order and identify so they are returned to their original positions.

Installation

1. Install push rods in their original positions, making sure they are fully seated in tappet push rod seats.

   NOTE: Install copper colored end of push rod toward rocker arm.

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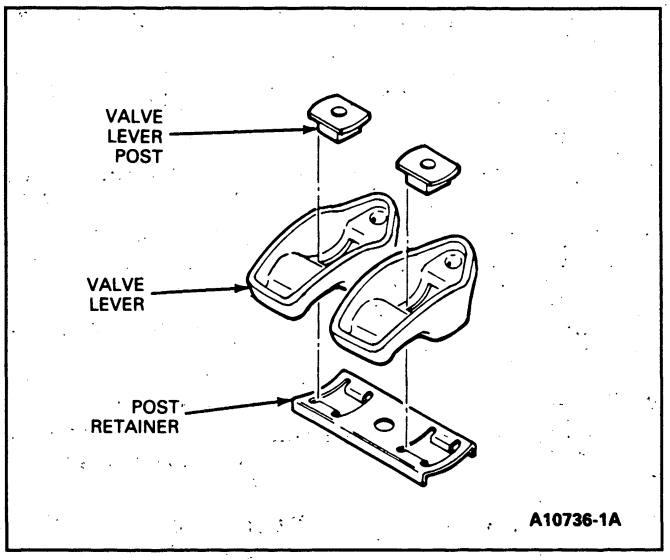


FIG. 60 Rocker Arm Assembly

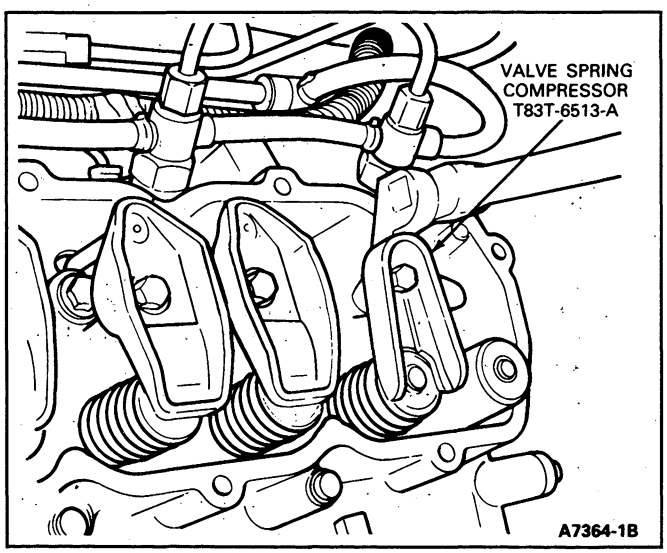


FIG. 61 Valve Spring Removal

2. Install valve rocker arms and posts in their original positions. (Fig. 61). Apply Polyethylene grease D0AZ-19584-A or equivalent, to valve stem tips.
3. Install valve rocker arm post attaching bolts as follows:
   a. Turn engine over by hand until timing mark is at 11:00 o'clock position as viewed from front of engine.
   b. Install all rocker arm post attaching bolts, and tighten to 27 N·m (20 ft-lb).
4. Clean valve covers with clean solvent and install new gaskets.
5. Install valve covers on cylinder heads. Tighten attaching screws to 8 N·m (6 ft-lb).
6. Raise vehicle.
7. Raise engine, remove wood block and lower engine onto No. 1 crossmember, if required.
8. Install insulator attaching washers and nuts and tighten to specification, if required.
9. Lower vehicle.

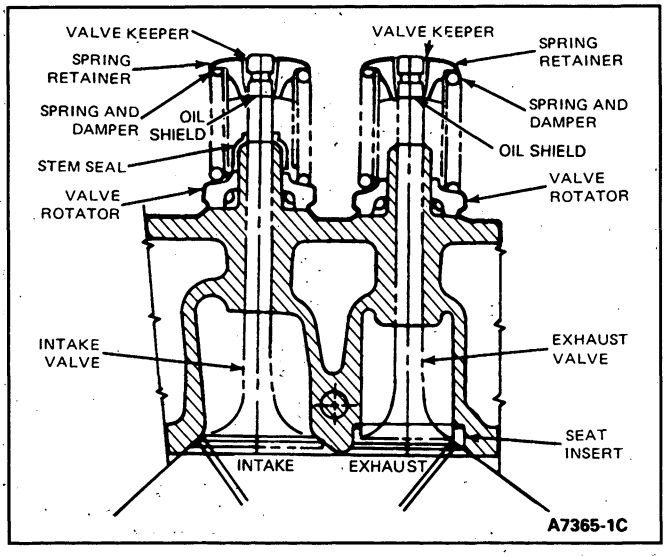


FIG. 62 Valve Spring Assembly

10. Install transmission filler tube and tighten to specification. Install transmission oil dipstick, if required.
11. Install engine oil dipstick tube and valve cover bracket. Tighten fasteners to specification. Install engine oil dipstick.
12. Install radiator fan shroud halves, if required. Refer to Section 27-04, Radiators.
13. Install ground cables to both batteries.
14. Run engine and inspect for oil leaks.

Valve Spring, Retainer and Stem Seal

Broken valve springs or damaged valve stem seals and retainers may be replaced without removing the cylinder head, provided damage to the valve or valve seat has not occurred. Refer to the following procedure.

Removal

1. Remove the required rocker arm(s).
2. Remove glow plug(s) with Glow Plug Socket D83T-6002-A or equivalent.
3. Install an air line with the adapter from Rotunda Compression Tester 014-00701 or equivalent, into the glow plug hole and turn on the air supply.
4. Install spring compressor using Spring Compressor T83T-6513-A or equivalent, as shown in Fig. 61. Compress valve spring and remove retainer locks, oil shield spring retainer, valve spring and damper spring (Fig. 62).

   NOTE: It may be necessary to strike valve stem end with a plastic tipped hammer to loosen valve retainer locks.
5. Remove valve stem seal and valve rotators.
6. Air pressure will force the piston to bottom of the cylinder and any removal of air pressure will allow valve(s) to fall into cylinder. A rubber band, tape or string wrapped around end of valve stem will prevent this condition and will still allow enough travel to check the valve for binding.

Installation

1. Inspect cylinder head and valve assemblies, as outlined. Inspect the valve stem for damage.

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Rotate the valve and check valve stem tip for eccentric movement during rotation. Move valve up and down through normal travel in valve guide and check stem for binds. If valve has been damaged, it will be necessary to remove cylinder head for repairs, as outlined. Inspect valve retainer locks for excessive wear, and replace in pairs, as necessary.

NOTE: When installing a new valve, always use new retainer locks.

2. If condition of valve proved satisfactory, hold valve in closed position and pressurize cylinder by applying compressed air to adapter installed in glow plug hole.
3. Lubricate valve stem with recommended engine oil.
4. Install valve rotators as shown in Fig. 63.
5. For the intake valves only, install valve stem seals by installing the clear plastic valve seal guide as shown in Fig. 63. Install the valve stem seal by hand until it rests on the end of the valve guide (Fig. 64). Use Valve Stem Seal Replacer T83T-6571-A or equivalent to align the seal over the end of the valve guide as shown in Fig. 63.

CAUTION: Apply only steady hand pressure on Valve Stem Seal Replacer T83T-671-A or equivalent until the seal bottoms squarely on the valve guide.

6. Remove the plastic valve seal guide. Install the nylon oil shield (Fig. 62), into the valve spring retainer (Fig. 66), applying pressure on shield until it snaps into place.

CAUTION: If the nylon oil shield is not properly installed in the valve spring retainer, it will float and cause excessive oil consumption.

NOTE: Intake and exhaust valve stem oil shields are different. The intake valve oil shield is much smaller than the exhaust valve oil shield. These oil shields are not interchangeable.

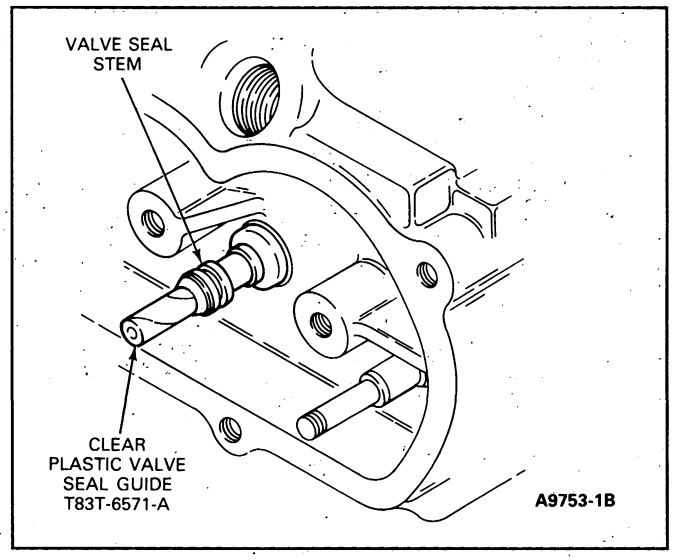


FIG. 64 Intake Valve Seal Installed over Valve Seal Guide

7. Place spring in position over valve and install valve spring retainer assembly. Compress valve spring and install valve spring retainer locks. Verify that the locks are correctly seated. Remove valve spring compressor.
8. Apply Multi-Purpose Grease D0AZ-19584-AA or equivalent, to tips of valve stem and push rods.
9. Install required rocker arm(s) and push rod(s) following instructions under Rocker Arm Installation.
10. Install glow plugs using Glow Plug Socket D83T-6002-A or equivalent, and tighten to 16 N·m (12 ft-lb).

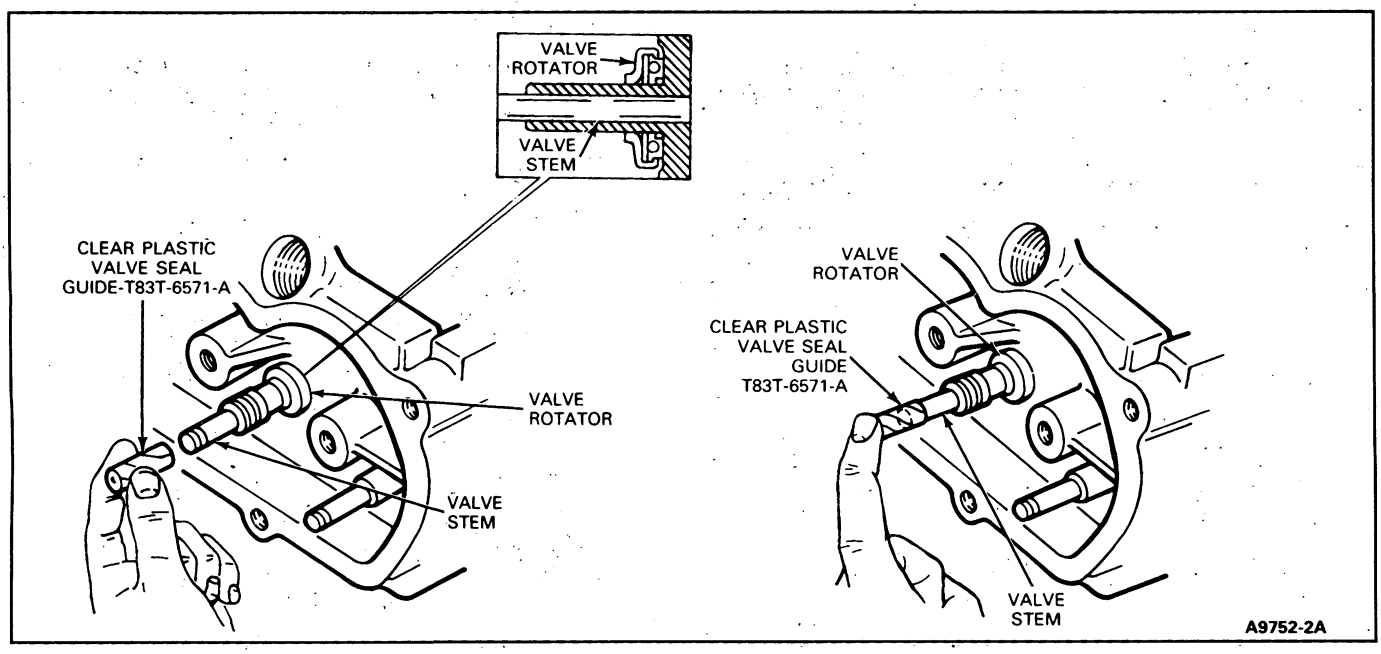


FIG. 63 Valve Seal Guide Installation

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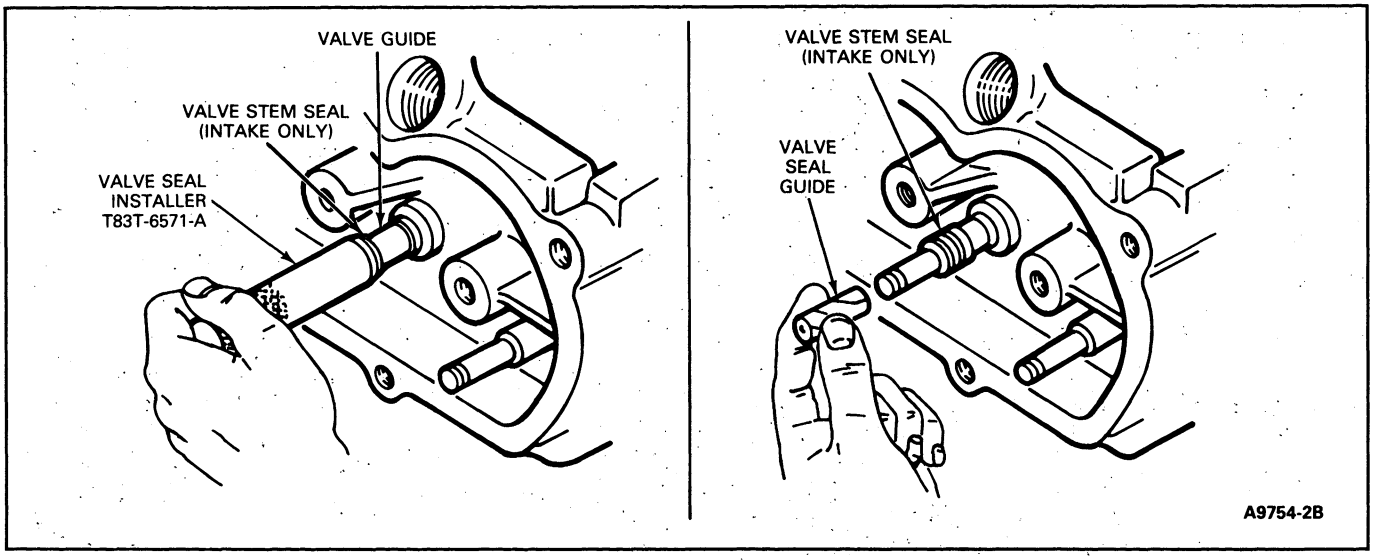


FIG. 65 Installing Valve Stem Seal Using Installer Tool T83T-6571-A

Fuel Supply Pump

Removal

1. Loosen threaded connections with proper size wrench (flare nut wrench preferred) and tighten snugly. Do not remove lines at this time.
2. Loosen mounting bolts one to two turns. Apply force with hand to loosen fuel pump if gasket is stuck. Rotate engine, by "nudging" starter, until fuel pump cam lobe is at low position. At this position, spring tension against fuel pump bolts will be greatly reduced.
3. Disconnect fuel supply pump inlet, outlet, and fuel return line.

   WARNING: USE CARE TO PREVENT COMBUSTION OF SPILLED FUEL.
4. Remove fuel pump attaching bolts. Remove pump and gasket. Discard old gasket.

Installation

1. Remove all fuel pump gasket material from engine and from fuel supply pump if installing original pump.
2. Install attaching bolts into fuel supply pump and install a new gasket onto bolts. Position fuel supply pump to mounting pad. Turn attaching bolts alternately and evenly. Tighten to specification.

   NOTE: Cam must be at low position before attempting to install fuel supply pump. If it is difficult to start the mounting bolts due to spring action of the fuel pump, turn crankshaft by hand 360 degrees to relocate camshaft lobe. Then, proceed with fuel supply pump installation. Install with lever on bottom side of cam.
3. Install fuel outlet line. Start fitting by hand to avoid crossthreading. Tighten to specification.
4. Install inlet line and tighten hose clamp to specification.
5. Start engine and observe all connections for fuel leaks for two minutes.
6. Stop engine and check all fuel supply pump fuel line connections. Check for oil leaks at pump mounting pad.

Injection Pump

NOTE: Before removing any fuel lines, clean exterior with clean fuel oil or solvent to prevent entry of dirt into engine when fuel lines are removed.

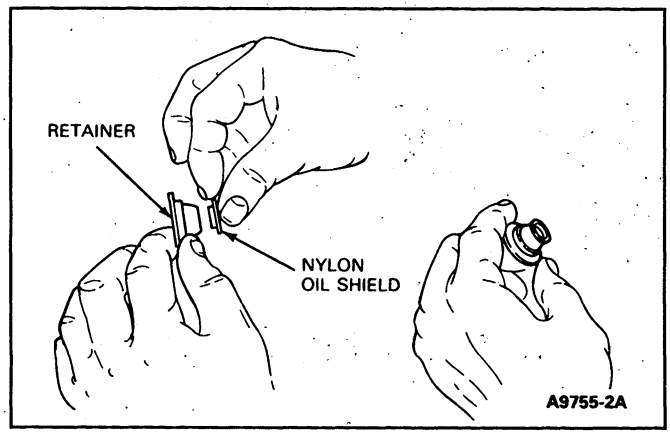


FIG. 66 Installing Nylon Oil Shield

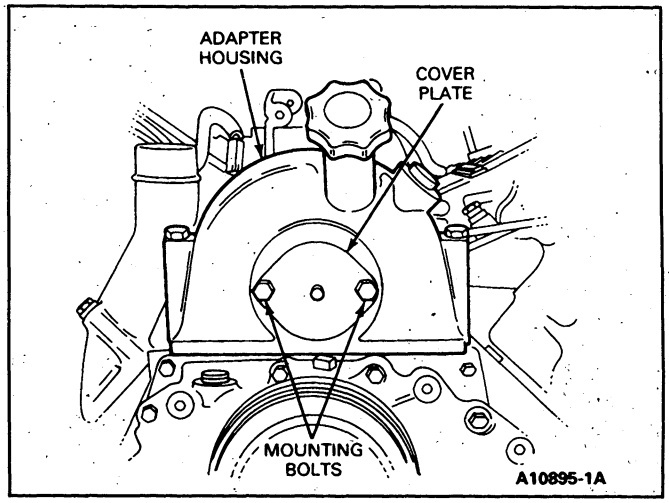


FIG. 67 Adapter Housing and Cover Plate

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CAUTION: Do not wash or steam clean engine while engine is running or still hot from running. Serious damage to injection pump could occur.

Removal

1. Disconnect battery ground cables from both batteries.
2. Remove engine cover on E-250—E-350.
3. Remove adapter housing cover plate by removing two retaining bolts (Fig. 67).
4. Remove bolts attaching injection pump to drive gear (Fig. 68).
5. Disconnect electrical connectors to injection pump.
6. Remove fast idle solenoid bracket assembly to provide access to injection pump mounting nuts (Fig. 69).
7. Disconnect accelerator cable and speed control cable from throttle lever, if so equipped.

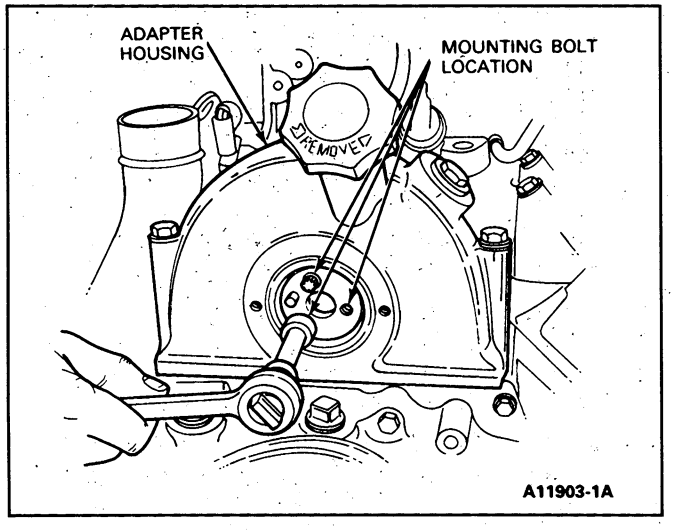


FIG. 68 Injection Pump Drive Gear Attaching Bolts

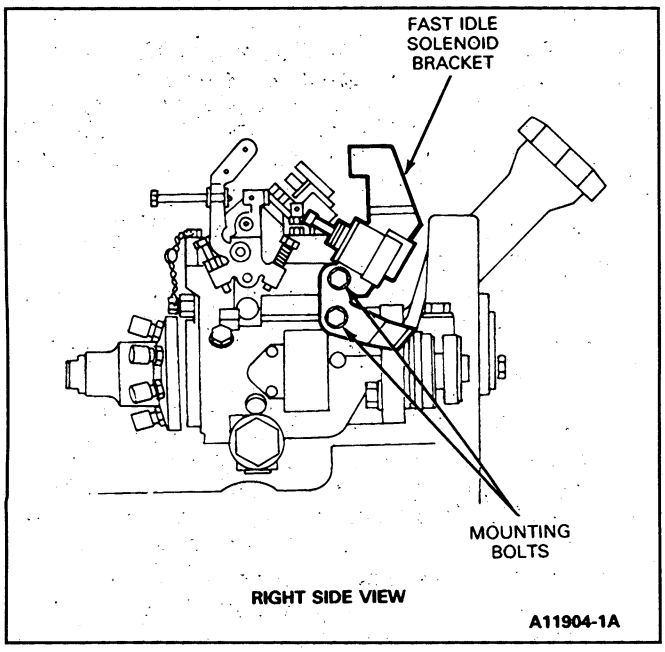


FIG. 69 Fast Idle Solenoid Bracket

8. Remove air cleaner and install intake opening cover, using Intake Manifold Cover T83T-9424-A, or equivalent.
9. Remove accelerator cable bracket (with cables attached) from intake manifold and position out of the way.

   NOTE: All fuel lines and fittings must be capped using Fuel System Protective Cap Set T83T-9395-A or equivalent, to prevent fuel contamination.
10. On E-250—E-350, disconnect fuel inlet line from the fuel filter.
11. On E-250—E-350, disconnect fuel return line from fuel filter.
12. On E-250—E-350, remove fuel filter bracket attaching bolts and remove fuel filter and bracket as an assembly.
13. Remove fuel return hose and clip from the 90 degree elbow at the governor cover. Cap opening at governor cover elbow (Fig. 70).
14. Remove fuel filter-to-injection pump fuel line and cap fittings.

    NOTE: It is not necessary to remove injection lines from injection pump to remove injection pump. If lines are to be removed, loosen injection line fittings at injection pump before removing it from engine.
15. Remove fuel injection lines from nozzles and cap lines and nozzles.
16. Remove three nuts attaching injection pump to injection pump drive gear cover using Injection Pump Mounting Wrench T86T-9000-C or equivalent (Fig. 71).
17. If injection pump is to be replaced, loosen injection line retaining clips and injection nozzle fuel lines with Fuel Line Nut Wrench T83T-9396-A or equivalent, and cap all fittings at this time with Fuel System Protective Cap Set T83T-9395-A or equivalent. Do not install injection nozzle fuel lines until new pump is installed in engine.

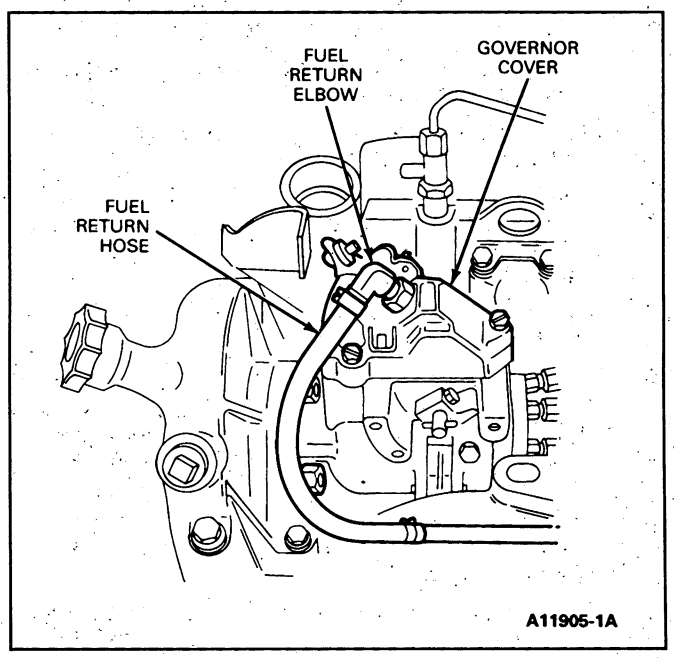


FIG. 70 Removing Fuel Return Line

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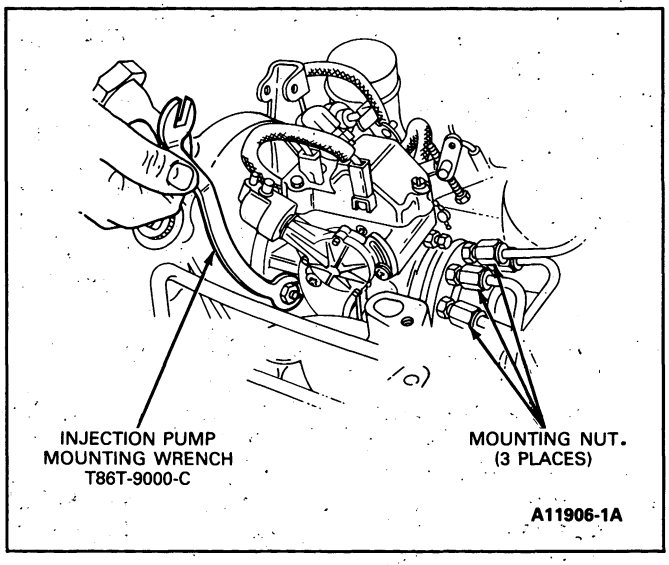


FIG. 71 Injection Pump Mounting Nut Removal

18. On F-250—F-350—F-Super Duty—Stripped Chassis, lift injection pump, with nozzle lines attached, up and out of engine compartment. (Fig. 60).

    CAUTION: Do not carry injection pump by injection nozzle fuel lines as this could cause lines to bend or crimp.

19. On E-250—E-350, remove injection pump through passenger compartment.

    NOTE: Use care to avoid spilling diesel fuel in passenger compartment.

    CAUTION: Do not carry injection pump by injection nozzle fuel lines as this could cause lines to bend or crimp.

Installation

1. Install new O-ring onto drive gear end of injection pump.
2. On F-250—F-350 — F-Series Stripped Chassis, move injection pump down and into position.
3. On E-250—E-350, install injection pump from passenger compartment.

    NOTE: Use care to avoid spilling diesel fuel in passenger compartment.
4. Position alignment dowel on injection pump into alignment hole on drive gear (Fig. 68). If necessary, rotate pump drive shaft to align drive slot prior to installation.
5. Install bolts attaching injection pump to drive gear and tighten to specification.
6. Install nuts attaching injection pump to adapter. Align scribe lines on injection pump flange and injection pump adapter. Tighten nuts to specification using injection pump mount wrench T86T-9000-C or equivalent (Fig. 71).
7. If injection nozzle fuel lines were removed from injection pump, install at this time. Refer to Injection Nozzle Fuel Lines, Installation.
8. Remove caps from nozzles and fuel lines. Install fuel line nuts onto nozzles and tighten to specification using Fuel Line Nut Wrench Tool T83T-9396-A or equivalent.
9. Connect fuel inlet line from filter and fuel return line to injection pump and tighten nuts to specifications.
10. Install injection pump fitting adapter with a new O-ring.
11. Clean old sealant from injection pump elbow threads using clean solvent, and dry thoroughly. Start elbow into injection pump adapter, and then apply a light coating of Pipe Sealant With Teflon® D8AZ-19554-A or equivalent, on elbow threads.
12. Tighten elbow in injection pump adapter to a minimum of 8 N·m (6 ft-lb). Then tighten further, if necessary, to align elbow with injection pump fuel inlet line, but do not exceed 360 degrees of rotation or 13 N·m (10 ft-lb).
13. Remove caps and connect fuel filter-to-injection pump fuel line and tighten to specification.
14. On E-250—E-350, install fuel filter and bracket as an assembly and tighten bolts to specifications.
15. On E-250—E-350, install fuel filter return line and tighten clamp to specifications.
16. On E-250—E-350, install fuel filter inlet fuel line and tighten to specifications.
17. Install accelerator cable bracket to intake manifold and tighten to specifications.
18. Remove intake manifold cover and install air cleaner and tighten to specifications.
19. Connect accelerator and speed control cable, if so equipped, to throttle lever.
20. Install fast idle solenoid bracket assembly and tighten to specification.
21. Install electrical connectors on injection pump.
22. Clean adapter housing cover plate sealing surfaces.
23. Apply a 3.2mm (1/8-inch) bead of Silicone Rubber Sealant, D6AZ-19562-A, or equivalent in adapter housing grooves.

    NOTE: When applying Silicone Rubber Sealant, D6AZ-19562-A or equivalent always use the bead size specified and join the components within 15 minutes of application. After 15 minutes the sealant begins to "set-up", and sealing effectiveness may be reduced.
24. Connect ground cables to both batteries.
25. Run engine and check for fuel leaks.
26. If necessary, purge high-pressure fuel lines of air by loosening connector one-half to one turn and cranking engine until bubble-free fuel flows from connection.

    CAUTION: Keep eyes and hands away from nozzle spray. Fuel spraying from the nozzle under high pressure can penetrate the skin and cause infection. Medical attention should be provided immediately in the event of skin penetration.
27. Check and adjust injection pump timing as described in the Engine/Emissions Diagnosis* manual.

*Can be purchased as a separate item.

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Injection Nozzle Fuel Lines

Removal

NOTE: Before removing any fuel lines, clean exterior of each nozzle assembly and surrounding area with solvent to prevent entry of dirt into fuel system when fuel lines are removed. Blow dry with compressed air.

1. Disconnect ground cables from both batteries.
2. On E-250—E-350, remove engine cover.
3. Remove air cleaner and cap intake manifold opening with Intake Manifold Cover T83T-9424-A or equivalent.
4. Disconnect accelerator cable and speed control cable, if so equipped, from injection pump.
5. Remove accelerator cable bracket from intake manifold and position out of the way with cable(s) attached.

   NOTE: To prevent fuel system contamination, cap all fuel lines and fittings with Fuel System Protection Cap Set T83T-9395-A or equivalent.
6. Disconnect fuel line from fuel filter to injection pump and cap all fittings.
7. Disconnect and cap nozzle fuel lines at nozzles.
8. Remove fuel line clamps from fuel lines to be removed (Fig. 74).
9. Remove and cap injection pump inlet elbow.
10. Remove and cap inlet fitting adapter.
11. Remove injection nozzle lines, one at a time, from injection pump using Fuel Line Nut Wrench T83T-9396-A or equivalent.

    NOTE: Fuel lines must be removed following this sequence; 5-6-4-8-3-1-7-2. Install caps on each end of each fuel line and pump fitting as it is removed and identify each fuel line accordingly (Fig. 73).

Installation

1. Install fuel lines on injection pump, using Fuel Line Nut Wrench T83T-9396-A or equivalent, one at a time, and tighten to specification (Fig. 73).

   NOTE: Fuel lines must be installed in the sequence: 2-7-1-3-8-4-6-5 (Fig. 73).
2. Clean old sealant from injection pump elbow, using clean solvent, and dry thoroughly.
3. Apply a light coating of Pipe Sealant With Teflon® D8AZ-19554-A or equivalent, on elbow threads.

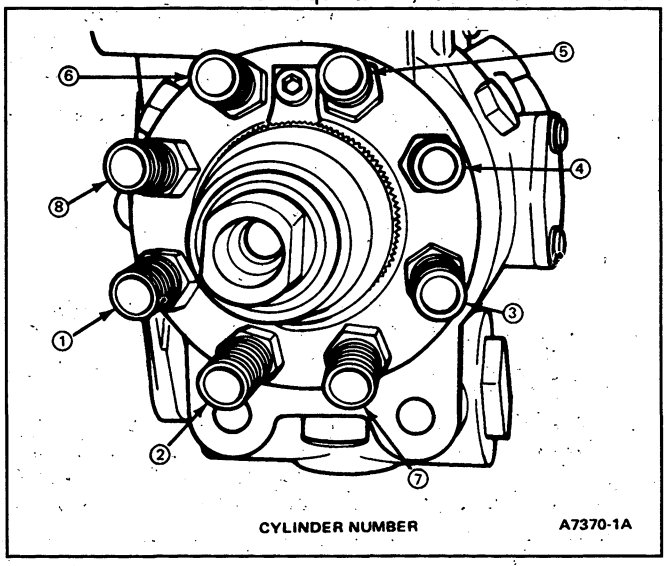


FIG. 73 Injection Pump Cylinder Numbering Sequence

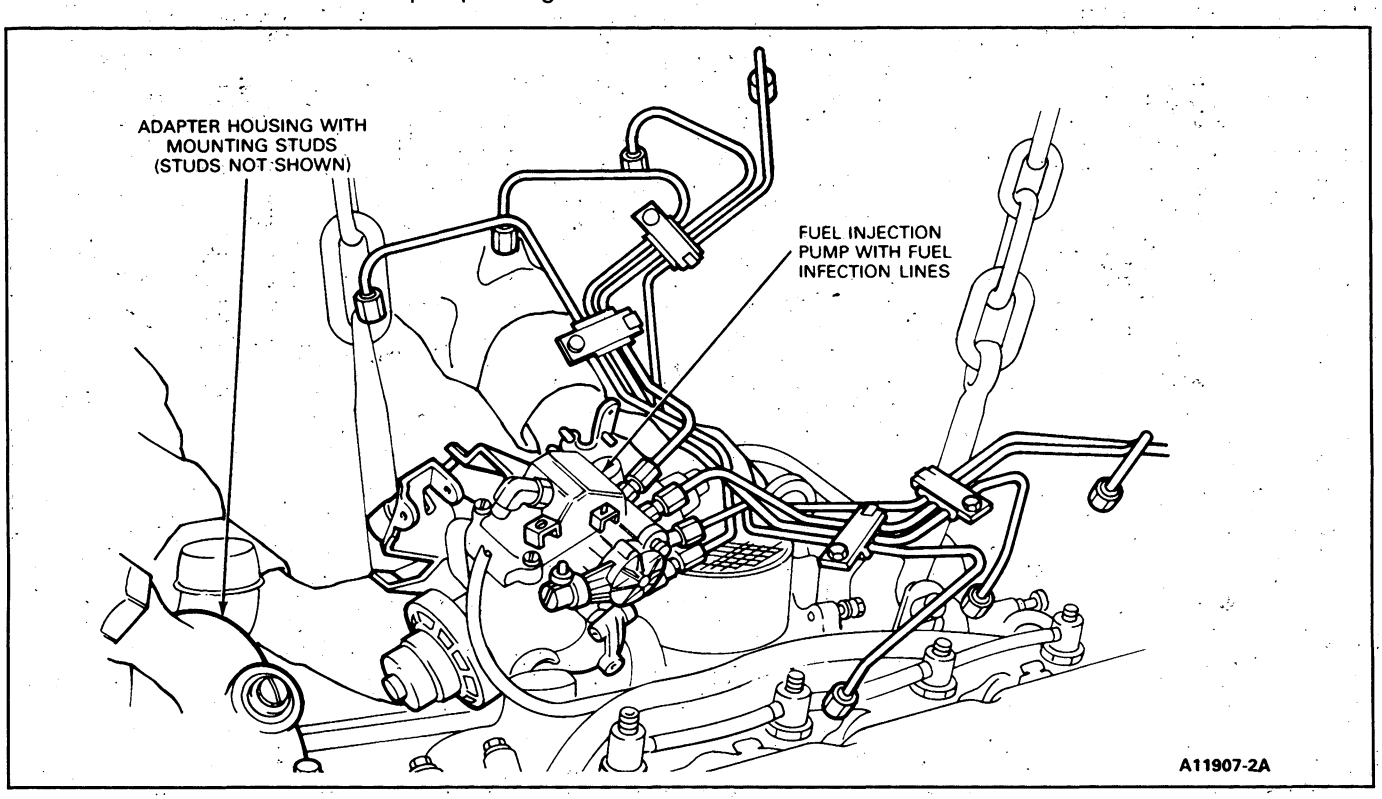


FIG. 72 Injection Pump Removal

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4. Install elbow in injection pump adapter and tighten to a minimum of 8 N·m (6 ft-lb). Tighten further, if necessary, to align elbow with injection pump fuel inlet line, but do not exceed 360 degrees of rotation or 13 N·m (10 ft-lb).
5. Remove caps from fuel lines and connect lines to nozzles. Tighten to 30 N·m (22 ft-lb), using Fuel Line Nut Wrench T83T-9396-A or equivalent.
6. Uncap and connect fuel line from fuel filter to injection pump and tighten to 30 N·m (22 ft-lb).
7. Install fuel line retaining clamps and tighten to specification (Fig. 74).
8. Install accelerator cable bracket onto intake manifold and tighten to 51 N·m (38 ft-lb).
9. Connect accelerator and speed control cable, if so equipped, to injection pump throttle lever.
10. Remove intake manifold cover, and install air cleaner and tighten to 51 N·m (38 ft-lb).
11. On E-250—E-350, install engine cover.
12. Connect ground cables to both batteries.
13. Run engine and check for fuel leaks.
14. If necessary, purge high-pressure fuel lines of air by loosening connector one-half to one turn and cranking engine until bubble-free fuel flows from connection.

CAUTION: Keep eyes and hands away from nozzle spray. Fuel spraying from the nozzle under high pressure can penetrate the skin and cause infection. Medical attention should be provided immediately in the event of skin penetration.

Injection Nozzles

Removal

NOTE: Before removing nozzle assemblies, clean exterior of each nozzle assembly and the surrounding area with solvent to prevent entry of dirt into engine when nozzle assemblies are removed. Also, clean fuel inlet and fuel leak-off piping connections. Blow dry with compressed air.

NOTE: On F-Series, remove and cap line sensor on number 1 cylinder to permit removal of fuel leak-off tees. On E-Series, remove and cap line sensor on number 4 cylinder to permit removal of fuel leak-off tee (Fig. 74).

1. Disconnect nozzle fuel inlet (high pressure) and fuel leak-off tees from each nozzle assembly and position out of the way. **Cover open ends of fuel inlet lines and nozzles to prevent entry of dirt with Fuel System Protective Cap Set T83T-9395-A or equivalent.**
2. Remove fuel leak-off lines as an assembly as follows. Refer to Fig. 74.
   A. Remove pump to fuel return tube hose at fuel return elbow cap elbow at pump. Disconnect hose (from leak-off tee to fuel filter) at leak-off tee.
   B. Loosen two fuel return tube retaining clamps, one at intake manifold and one at engine lifting

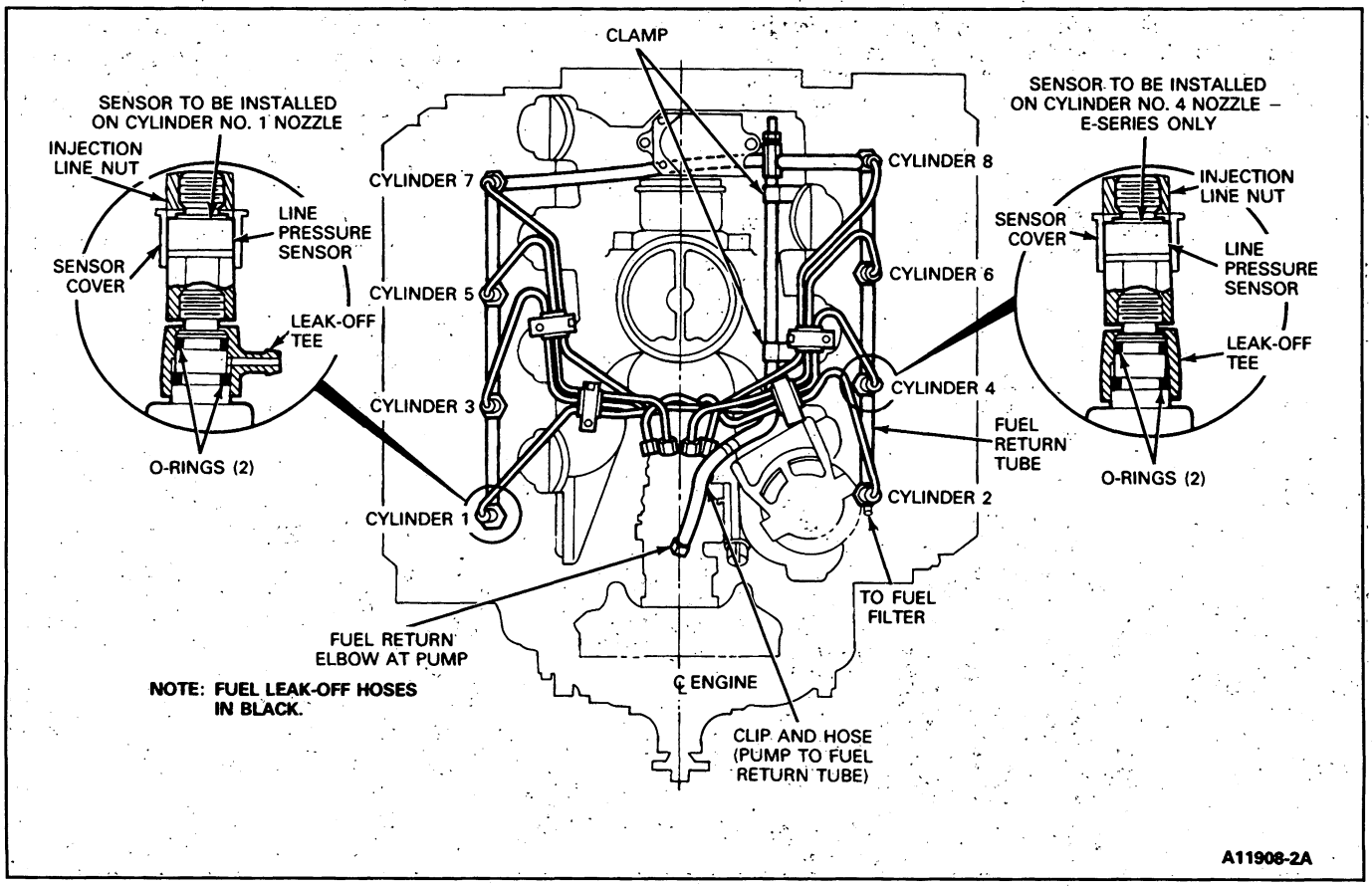


FIG. 74 Fuel Line Routing and Installation (E-Series shown)

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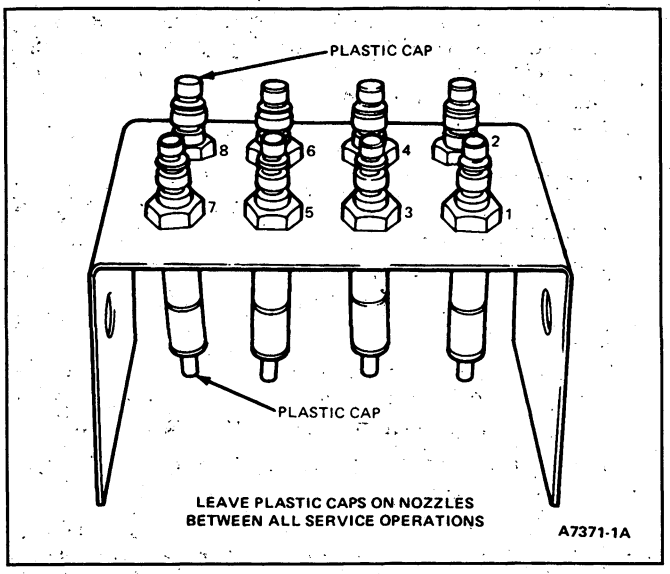


FIG. 75 Nozzle Holding Fixture

eye. Remove fuel return hose clamp at CDR valve bracket.

C. With clamps removed, remove return lines and tees as an assembly by lifting tees off nozzles.

3. Remove injection nozzles by turning counterclockwise. Pull nozzle assembly with copper washer from engine. **Be careful not to strike nozzle tip against any hard surface during removal. Cover nozzle assembly fuel inlet opening and nozzle tip with plastic cap to prevent entry of dirt, Fuel System Protective Cap Set T83T-9395-A or equivalent.**

   NOTE: Remove copper injector nozzle gasket from nozzle bore with O-Ring T71P-19703-C or equivalent, if not attached to nozzle tip.

4. Place nozzle assemblies in a fabricated holder as they are removed from the heads, (Fig. 75). The holder should be marked with numbers corresponding to the cylinder numbering of the engine. Use of this holder permits nozzle installation into original location in the cylinder heads.

Installation

1. Thoroughly clean nozzle bore in cylinder head before reinserting nozzle assembly with Nozzle Seat Cleaner T83T-9527-A or equivalent. Pay particular attention to seating surface, in order that no small particles of metal or carbon will cause assembly to be cocked or permit blow-by of combustion gases. Blow out particles with compressed air.

2. Remove protective cap and install a new copper gasket nozzle assembly, with a small dab of Polyethylene Grease D0AZ-19584-A or equivalent.

   NOTE: Anti-Seize Compound or equivalent should be used on nozzle threads to aid installation and future removal.

3. Install nozzle assembly into cylinder head nozzle bore.

   CAUTION: Be careful that nozzle tip does not strike against recess wall.

4. Tighten nozzle assembly to 47 N·m (35 ft-lb).

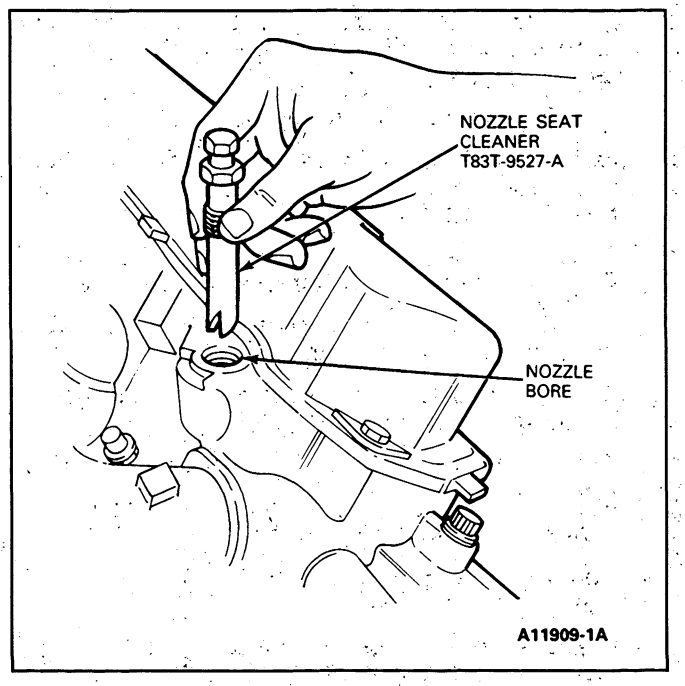


FIG. 76 Cleaning Nozzle Seats

5. Remove protective caps from nozzle assemblies and fuel lines.

6. Install leak-off tees and lines as an assembly by lowering onto nozzles. Connect clip and hose to fuel return elbow at pump. Install line to retaining clamps (Fig. 74).

   NOTE: Install two new O-ring seals for each fuel return tee.

7. Connect high pressure fuel line(s) and tighten to specification using Fuel Line Nut Wrench T83T-9396-A or equivalent.

8. Start engine.

9. If necessary, purge high-pressure fuel lines of air by loosening connector one-half to one turn and cranking engine until bubble-free fuel flows from connection.

   CAUTION: Keep eyes and hands away from nozzle spray. Fuel spraying from the nozzle under high pressure can penetrate the skin and cause infection. Medical attention should be provided immediately in the event of skin penetration.

10. Check for fuel leakage at high-pressure connections.

Intake Manifold, Valley Pan and Tappets

Removal

1. Disconnect ground cables from both batteries.
2. On E-250—E-350, remove engine cover.
3. Remove air cleaner and install intake manifold cover, using Intake Manifold Cover T83T-9424-A or equivalent.
4. On E-250—E-350, disconnect fuel inlet line from the fuel filter.
5. On E-250—E-350, disconnect fuel return line from fuel filter.

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6. On E-250—E-350, remove fuel filter bracket attaching bolts and remove fuel filter and bracket as an assembly.
7. Remove injection pump, as outlined.
8. On F-250—F-350, remove fuel return hoses from No. 7 and No. 8 (rear) nozzles and remove return hose to fuel tank.
9. Remove glow plug harness and controller. Remove engine wiring harness from engine.

   NOTE: Remove engine harness ground cable from back of left cylinder head.
10. Remove bolts attaching intake manifold to cylinder heads and remove manifold (Fig. 77).
11. Remove CDR tube and grommet from valley pan.
12. Remove bolts attaching valley pan strap to front of engine block, and remove strap.
13. Remove valley pan drain plug and remove valley pan.
14. If tappets are being serviced, remove valve covers, rocker arms and push rods, as outlined.
15. Remove tappet guide retainer (Fig. 78).

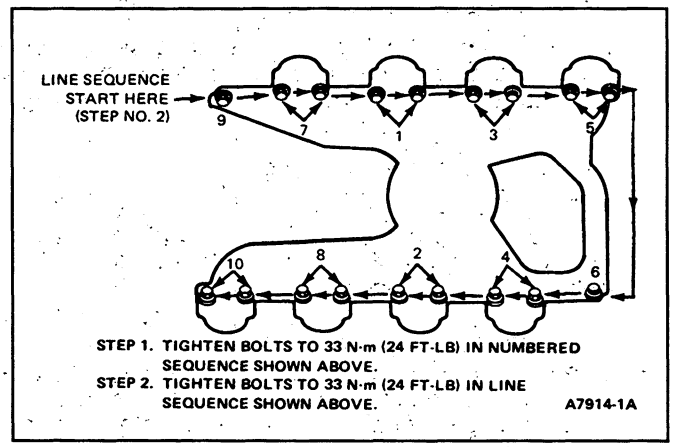


FIG. 77 Intake Manifold Attaching Bolts Tightening Sequence

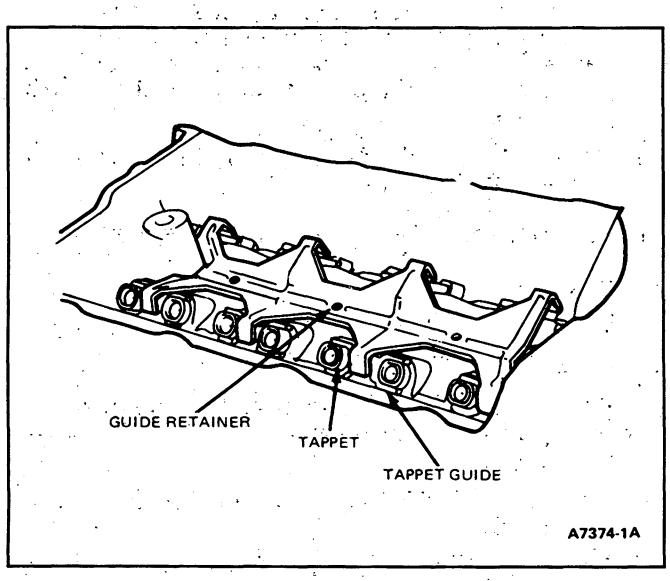


FIG. 78 Tappet Removal

NOTE: Tappets should be kept in order so they can be installed in their original position. Inspect and test each tappet separately to prevent intermixing the internal parts.

Installation

1. Lubricate tappets and bores with recommended quality engine oil and install tappets in their original positions.
2. Install tappet guides.
3. Install tappet guide retainer and tighten to specifications.
4. Position push rods, copper colored ends toward rocker arms, into their respective tappets making sure they are seated fully in push rod seats.
5. Install rocker arms and valve covers with new gaskets, as outlined.
6. Clean cylinder block gasket surfaces of any old Silicone Rubber Sealant or oil. Apply a 3.18mm (1/8 inch) bead of Silicone Rubber Sealant D6AZ-19562-A or equivalent, to each end of the cylinder block (Fig. 79).

   NOTE: When applying Silicone Rubber Sealant always use the bead size specified and join the components within 15 minutes of application. After 15 minutes the sealant begins to "set-up", and sealing effectiveness may be reduced.
7. Install new valley pan.
8. Install valley pan drain plug.
9. Install CDR tube and new grommet into valley pan.
10. Install new O-ring and new back-up ring on CDR valve.
11. Install valley pan strap onto front of valley pan and tighten to specification in Standard Torque Chart.
12. Install intake manifold and tighten to specifications using the two-step method shown in Fig. 77.
13. Install engine wiring harness on engine.

    NOTE: Connect engine wiring harness ground wire to rear of left cylinder head and tighten to specification.
14. Install glow plug controller and harness.
15. On E-250—E-350, install fuel filter and bracket as an assembly and tighten bolts to 33-52 N·m (24-39 ft-lb).
16. On E-250—E-350, install fuel filter return line and tighten clamp to specifications.

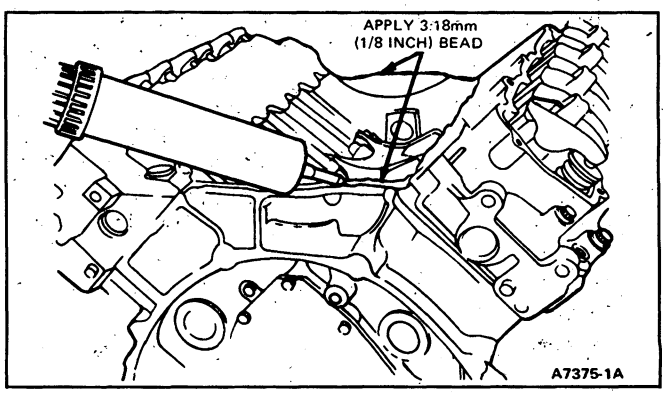


FIG. 79 Applying RTV Sealant

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17. On E-250—E-350, install fuel filter inlet fuel line and tighten to specifications.
18. Install injection pump, as outlined.
19. Connect fuel tank return hose and No. 7 and No. 8 nozzle fuel return hoses (Fig. 75).
20. Remove intake manifold cover and install air cleaner. Tighten to specification.
21. Install engine cover, E-250—E-350.
22. Connect ground cables to both batteries.
23. Run engine. Check for oil and fuel leaks.
24. If necessary, purge nozzle high-pressure fuel lines of air by loosening connector one-half to one turn and cranking engine until bubble-free fuel flows from the connection.

CAUTION: Keep eyes and hands away from nozzle spray. Fuel spraying from the nozzle under high pressure can penetrate the skin and cause infection. Medical attention should be provided immediately in the event of skin penetration.

Exhaust Manifolds

F-250—F-350—F-Super Duty

Removal

1. Disconnect ground cables from both batteries.
2. Raise vehicle.
3. Disconnect muffler inlet pipe from exhaust manifolds.
4. If right exhaust manifold is to be removed, lower vehicle at this time. If left exhaust manifold is to be removed, leave hoist up.
5. Remove exhaust manifold attaching bolts and manifold.

Installation

1. Clean mounting surfaces.
2. Apply anti-seize compound on exhaust manifold bolt threads and install left manifold with new gasket.

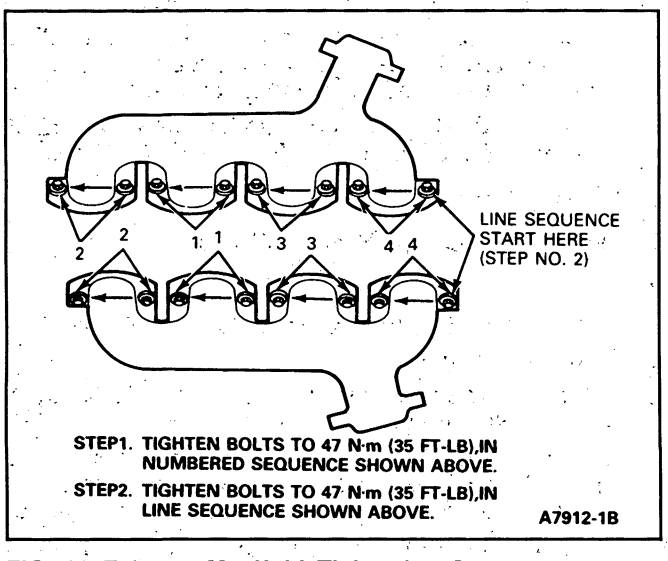


FIG. 80 Exhaust Manifold Tightening Sequence

3. Tighten bolts to specifications, using the two-step method shown in Fig. 80 and raise vehicle.
4. If right exhaust manifold is being installed, raise vehicle at this time, and repeat installation Steps 2 and 3.
5. Connect muffler inlet pipe to manifolds and tighten to specification.
6. Lower vehicle.
7. Connect battery ground cables to both batteries.
8. Run engine and check for exhaust leaks.

E-250—E-350

Removal

1. Open hood. Remove engine cover.
2. Disconnect battery ground cables from both batteries.
3. For RH manifold only, remove radiator fan shroud halves. Refer to Section 27-04, Radiators.
4. For RH manifold only, remove engine oil dipstick tube fasteners. Remove dipstick and tube.
5. For RH manifold only, remove transmission filler tube fasteners. Remove filler tube and dipstick.
6. Raise vehicle.

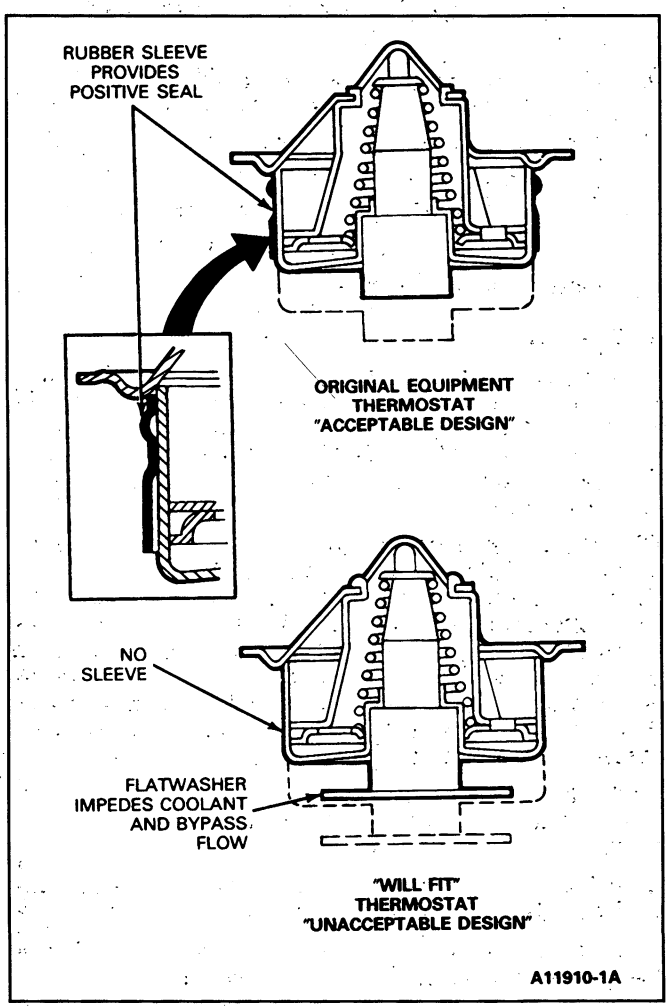


FIG. 81 Thermostat Design (Acceptable vs. Unacceptable)

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7. For RH manifold only, remove nuts attaching RH engine mount insulator to frame.
8. For RH manifold only, slightly raise RH side of the engine until fuel filter header touches vehicle sheet metal. Install suitable wood block between insulator and frame. Lower engine on block.
9. Remove muffler inlet pipe from exhaust manifolds.
10. Lower vehicle.
11. Remove bolts and manifold.

Installation

1. Apply anti-seize compound to manifold retaining bolts. Install manifold with new gasket.
2. Tighten bolts to specifications using the two-step method shown in Fig. 80.
3. Raise vehicle.
4. For RH manifold only, raise engine, remove wood block and lower engine onto No. 1 crossmember.
5. For RH manifold only, install insulator attaching washers and nuts. Tighten to specification.
6. Install muffler inlet pipe to exhaust manifolds and tighten to specification.
7. Lower vehicle.
8. For RH manifold, install transmission filler tube and tighten to specification. Install transmission oil dipstick.
9. Install engine oil dipstick tube and tighten fasteners to specification. Install engine oil dipstick.
10. For RH manifold, install radiator fan shroud halves. Refer to Section 27-04, Radiators.
11. Connect ground cables to both batteries.
12. Run engine and check for exhaust leaks.
13. Install engine cover and close hood.

Thermostat

A poppet-type thermostat is used with the engine. When the thermostat is closed, coolant flows to the water pump through a bypass passage at the front of the engine. When the thermostat is open, coolant flows through the coolant outlet elbow (thermostat housing) to the radiator.

CAUTION: Replacement thermostats other than the specified Motorcraft, or International Harvester thermostats may result in engine overheat damage. The specified thermostat does not contain an internal bypass, since the by-pass is located in the cylinder block. Therefore, whenever the thermostat is replaced, it is mandatory that only Motorcraft E5TZ-8575-C or International Harvester 1807945-C1 thermostat be installed.

The thermostat is a high temperature thermostat for use with a mixture of water and permanent-type anti-freeze.

CAUTION: Do not attempt to repair the thermostat. It should be replaced if it is not operating properly.

Check the thermostat before installing it, following the procedure described in this Section.

Removal

1. Disconnect ground cables from both batteries.
2. Drain coolant from radiator until coolant level is below thermostat. Refer to Section 27-02 Cooling System Service.
3. Loosen and remove alternator and vacuum pump drive belts.
4. Remove alternator. Position alternator out of the way.
5. Remove vacuum pump and bracket. Position pump out of the way.
6. Remove all but the lowest alternator/vacuum pump mounting casting bolt. Loosen the lowest bolt and pivot the alternator/vacuum pump casting outboard.
7. Remove the water outlet housing attaching bolts. Bend the radiator upper hose upward and remove the thermostat and gasket.

Installation

1. Clean the water outlet housing gasket surfaces. Coat a new outlet housing gasket with Perfect Seal Sealing Compound B5A-19554-A or equivalent. Position the water outlet housing gasket on intake manifold opening.
2. Install thermostat in crankcase opening with the copper pellet or element toward engine and the thermostat flange positioned in the recess. If thermostat is improperly installed, it will cause a restricted flow of coolant.
3. Position the water outlet housing against the crankcase. Install and tighten the attaching bolts to specification.
4. Reposition the alternator/vacuum pump casting. Install attaching bolts.
5. Install vacuum pump with bracket and tighten to specification.
6. Install alternator and drive belt.
7. Install vacuum pump drive belt.
8. Adjust alternator and vacuum pump drive belts to specification. Refer to Section 27-06, Accessory Drive Belt Service.
9. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service.
10. Connect ground cables to both batteries.
11. Operate the engine until normal operating temperature is reached, then check the coolant level. Inspect cooling system for leaks.

WARNING: DO NOT STAND IN LINE OR NEAR RADIATOR FAN WHEN REVVING ENGINE.

Cylinder Heads

RH Side Described, LH Side Similar

Removal

1. Disconnect ground cables from both batteries.
2. Drain cooling system.
3. Remove radiator fan shroud. Refer to Section 27-04, Radiators.
4. Remove radiator fan and clutch assembly using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B or equivalents.

CAUTION: LH thread. Remove by turning nut clockwise.

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5. Disconnect alternator wiring from alternator. Disconnect wiring harness electric connector from top of fuel filter/fuel heater/water separator.
6. Remove alternator adjusting bolt and pivot bolt. Remove alternator.
7. Remove vacuum pump adjusting bolt and pivot bolt. Remove vacuum pump.
8. Remove fuel filter inlet, outlet and return lines. Cap lines and fittings with Fuel System Protection Cap Set T83T-9395-A or equivalent, (F-250—F-350, RH side only).
9. Remove alternator and vacuum pump mounting bracket. On F-250—F-350, remove fuel filter bracket with filter attached (RH side only).
10. Remove heater hose from cylinder head.
11. Remove injection pump, as outlined.
12. Remove intake manifold and valley cover, as outlined.
13. Raise vehicle.
14. Disconnect muffler inlet pipe from exhaust manifolds.
15. Remove bolt attaching transmission oil dipstick tube to cylinder head (RH side only).
16. Lower vehicle.
17. Remove engine oil dipstick tube-fasteners (RH side only).
18. Remove right hand exhaust manifold, as outlined.
19. Remove engine oil dipstick, dipstick tube and O-ring (RH side only).
20. Remove valve cover, rocker arms and push rods, as outlined.
21. Remove nozzles and glow plugs, as outlined.
22. Remove bolts attaching cylinder head to engine block.
23. Attach Engine Lifting Brackets T70P-6000 or equivalent, to each end of cylinder head.
24. For F-250—F-350, install lifting sling to lifting eyes and carefully lift cylinder head out of engine compartment.
25. For E-250—E-350, install suitable bar through rings on lifting eyes. With an assistant, carefully lift cylinder head and remove (Fig. 82).
26. Remove head gasket carefully to prevent damage to cylinder head locating dowel sleeves.

    CAUTION: Prechambers may fall out of cylinder head upon removal.
27. Remove prechambers using a 6.35mm x 203mm (1/4 inch x 8 inch) brass drift and suitable hammer (Fig. 83).
28. Place cylinder head in suitable holding Fixture.

    NOTE: Be careful not to damage the cylinder head gasket surface.
29. Install Valve Spring Compressor T83T-6513-A or equivalent, compress valve spring, and remove valve keeper, (Fig. 61).

    NOTE: It may be necessary to strike valve stem end with a light, soft hammer to loosen valve keepers.

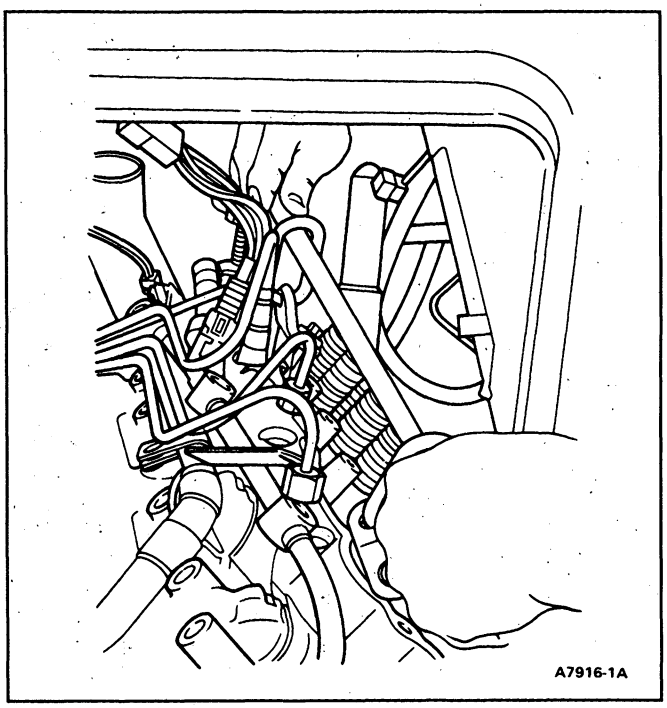


FIG. 82 Cylinder Head Removal—E-250—E-350

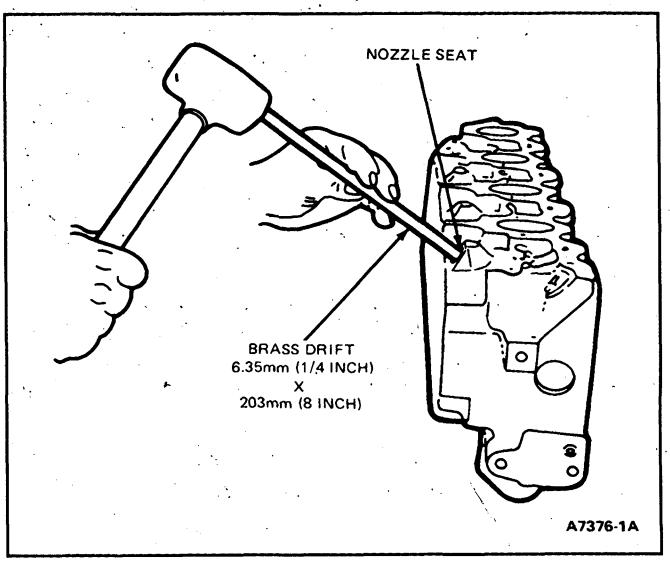


FIG. 83 Prechamber Removal

30. Release spring compressor and remove spring retainer, valve spring and damper assembly, (Fig. 62).

    NOTE: Keep valves and their related parts together so they may be installed in their original positions.
31. Remove valve seal, valve rotators and valves.

    NOTE: Remove any burrs from valve stem before removing valves to prevent damage to the valve bore.

Installation

1. Clean and inspect cylinder head and valves, as outlined.
2. Clean and inspect cylinder head gasket surface for cracks and flatness, as outlined.

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NOTE: To avoid erroneous readings, remove pre-combustion chamber inserts prior to inspection of cylinder head gasket surface.

3. Install valves, springs, retainers and stem seals, as outlined.
4. Clean and inspect prechambers and ports for cracks. Install or replace prechambers as necessary. Refer to Overhaul—Cylinder Head Assembly in this Section.
5. Apply a light coating of Steering Linkage Lube D4AZ-19590-A or equivalent, to mounting edge of prechamber and install prechamber into head. Lightly tap with plastic-tipped hammer, if necessary.
6. Clean and inspect engine block head gasket surface for cracks and flatness.
7. Position new cylinder head gasket on engine block using locating dowels. Install gasket with silver stamped "This Side Up" facing installer.
8. On F-Series, attach lifting sling and brackets to cylinder head. On E-Series, position bar through rings on lifting eyes. Carefully lower cylinder head onto engine block.

   CAUTION: Use care when installing cylinder head to prevent pre-chambers from falling into cylinder bores. Do not slide cylinder head across gasket. Sliding head may damage seals and result in coolant or oil leakage.
9. Lightly lubricate cylinder head bolt threads and mating surfaces of bolt heads and washers with engine oil.

   CAUTION: Do not use anti-seize compounds, grease or any other lubricant except engine oil. Other lubricants have an adverse effect on torque value.
10. Install cylinder head retaining bolts and washers. Tighten to specifications as shown in Fig. 84.
11. Install push rods, copper colored ends toward rocker arms, making sure push rods are fully seated into tappets.
12. Install rocker arms and valve covers, as outlined.
13. Install valley pan and intake manifold, as outlined.

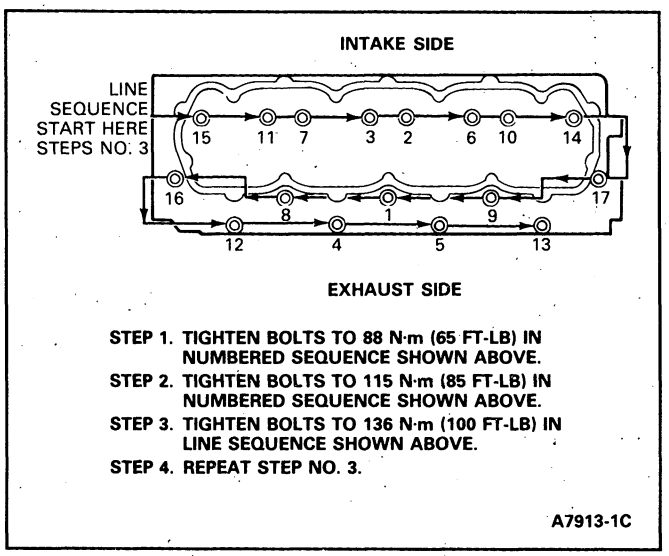


FIG. 84 Cylinder Head Bolt Tightening Sequence

14. Install injection pump, as outlined.
15. Connect heater hose to cylinder head and tighten clamp to specification.
16. Install fuel filter/fuel heater/water separator with bracket (F-250—F-350, RH side only), and/or alternator and vacuum pump bracket and tighten to specification.
17. Remove protective caps and install fuel filter inlet, outlet and return lines. Tighten to specifications.
18. Loosely install engine oil dipstick tube and O-ring into cylinder block (RH side only).
19. Raise vehicle.
20. Install RH hand exhaust manifold, as outlined. Install fasteners holding engine oil dipstick tube in position.
21. Install bolt attaching transmission oil dipstick to cylinder block and tighten to specification (RH side only).
22. Connect muffler inlet pipe to exhaust manifolds and tighten to specification.
23. Lower vehicle.
24. Install vacuum pump.
25. Install alternator and drive belt.
26. Install vacuum pump and drive belt.
27. Adjust alternator and vacuum pump drive belts to specifications. Refer to Section 27-06, Accessory Drive Belt Service.
28. Connect alternator wiring harness. Connect wiring harness top of fuel filter/fuel heater/water expansion.
29. Remove intake manifold cover and install air cleaner. Tighten to specification.
30. Connect ground cables to both batteries.
31. Refill and bleed cooling system. Refer to Section 27-02, Cooling System Service.
32. Run engine and check for fuel, coolant and exhaust leaks.
33. If necessary, purge high-pressure fuel lines of air by loosening connector one half to one turn and cranking engine until bubble-free fuel flows from connection.

    CAUTION: Keep eyes and hands away from nozzle spray. Fuel spraying from the nozzle under high pressure can penetrate the skin and cause infection. Medical attention should be provided immediately in the event of skin penetration.
34. Install radiator fan and clutch assembly using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B or equivalents.

    CAUTION: LH thread. Tighten by turning nut counterclockwise.
35. Install radiator fan shroud. Refer to Section 27-04, Radiators.

Engine Oil Filter

Removal

1. Raise vehicle.
2. Remove oil filter, using a suitable oil filter wrench.

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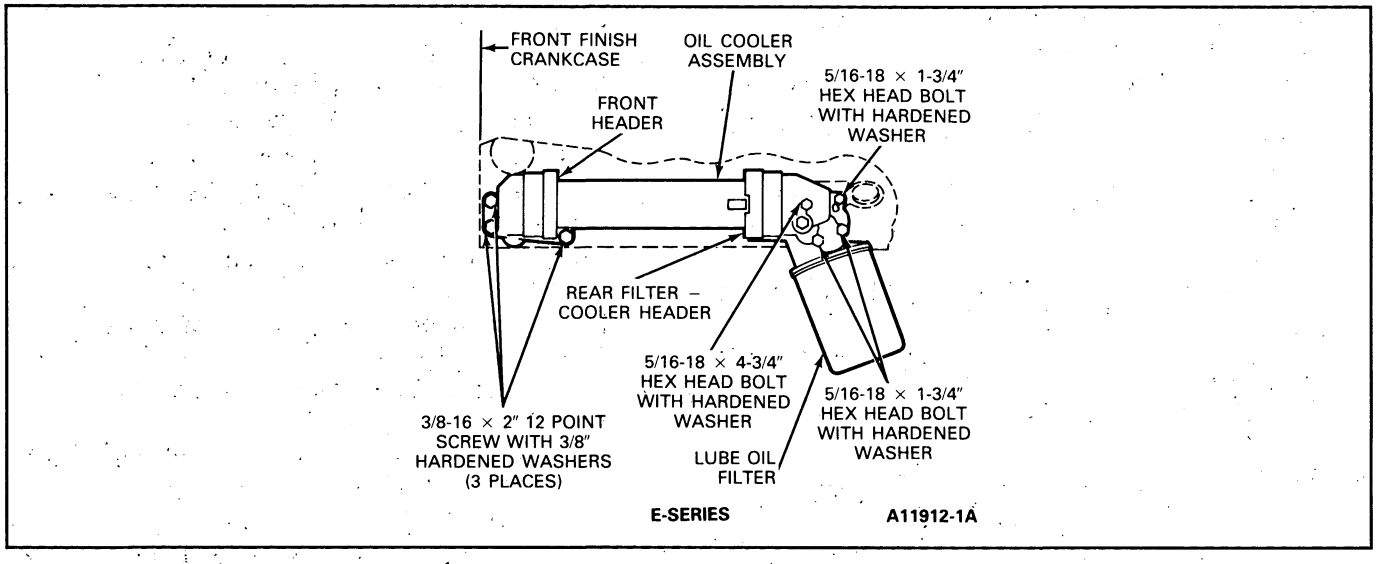


FIG. 85 Oil Cooler Assembly (E-Series Shown)

Installation

1. Clean gasket mating surface on oil filter flange.
2. Lightly coat sealing gasket with clean engine oil.
3. Install oil filter until seal contacts filter flange and tighten 1 1/4 to 2 additional turns.
4. Lower vehicle.
5. Check engine oil level, and add as required.
6. Run engine and check for oil leaks.

Engine Oil Cooler

NOTE: If necessary refer to Oil Cooler Leakage Test and perform as outlined.

Removal

1. Disconnect ground cables from both batteries.
2. Drain cooling system.
3. Remove radiator fan shroud. Refer to Section 27-04, Radiators.
4. Remove fan and clutch assembly using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B, or equivalents.

   CAUTION: LH thread. Remove by turning nut clockwise.
5. Raise vehicle.
6. Drain engine oil and remove oil filter. Do not install drain plug.
7. Remove nut attaching LH engine mount insulator to frame (F-250—F-350 only).
8. Slightly raise LH side of the engine and install a 25mm (one inch) wood block between insulator and frame. Lower engine on block (F-250—F-350 only).
9. Remove bolts attaching oil cooler to engine block and remove engine oil cooler.

Installation

1. Assemble cooler and headers. Install engine oil cooler assembly with new gaskets and tighten to specification.

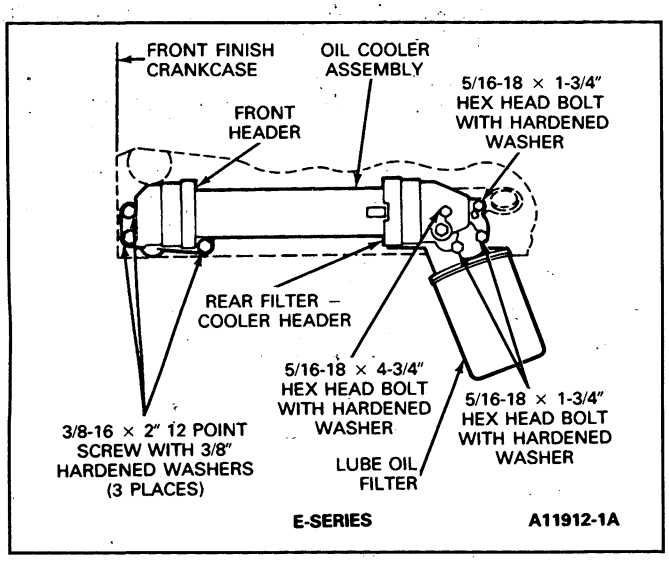


FIG. 86 Oil Cooler Installation E-Series

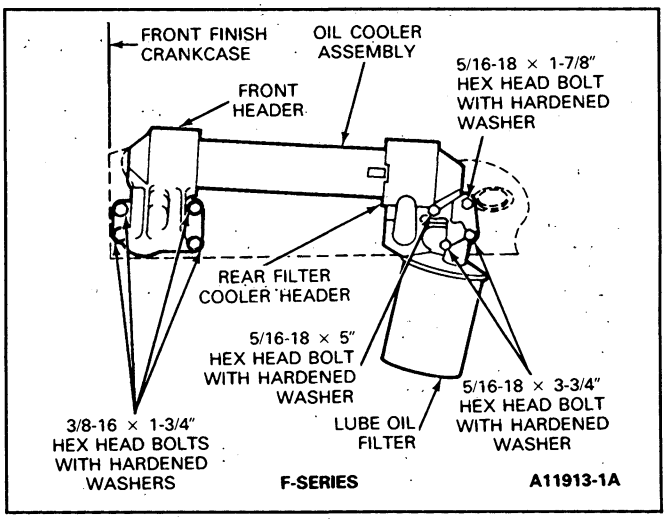


FIG. 87 Oil Cooler Installation F-Series

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NOTE: Four O-rings are used on all oil coolers (F-Series and E-Series).

CAUTION: The inner O-ring must be installed on the header (not on the bundle) to avoid cutting the inner O-ring during assembly (Fig. 16).

2. Raise engine, remove wood block and lower engine onto No. 1 crossmember (F-250—F-350 only).
3. Install insulator attaching washer and nut. Tighten to specification (F-250—F-350 only).
4. Lubricate oil filter gasket and install new oil filter until seal contacts filter flange. Tighten filter 1 1/4 to 2 additional turns. Install drain plug and tighten to specification.
5. Prime the entire engine lubricating system to fill the oil cooler, oil filter and cylinder block galleries with the specified type and grade of oil.

   NOTE: Priming the lubricating system will minimize the possibility of scuffing or heat build-up during initial engine operation which could lead to immediate or low mileage failure.
6. Lower vehicle.
7. Check the engine oil level and fill as necessary with the specified type and grade of oil.
8. Fill and bleed the cooling system. Refer to Section 27-02, Cooling System Service.
9. Install fan and clutch assembly using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B or equivalents.

   CAUTION: LH thread. Turn nut counterclockwise to tighten.

   Tighten nut to specifications.
10. Install radiator fan shroud. Refer to Section 27-04, Radiators.
11. Connect ground cables at both batteries.
12. Run engine and check for oil and coolant leaks.

Oil Pan, Oil Pump and Oil Pick-Up Tube

Removal

1. Disconnect ground cables from both batteries.
2. Remove engine oil level dipstick.
3. Remove transmission oil level dipstick, if so equipped.
4. Remove air cleaner and install intake opening cover using Intake Manifold Cover T83T-9424-A or equivalent.
5. Remove fan and clutch assembly using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B or equivalents.

   CAUTION: LH thread. Remove by turning nut counterclockwise.
6. Drain cooling system.
7. Disconnect lower radiator hose.
8. Disconnect power steering return hose from pump. Plug hose and pump to prevent contamination of the system.
9. Disconnect alternator wiring harness and fuel line heater connector from alternator.
10. Raise vehicle.
11. Disconnect and plug transmission oil cooler lines from radiator, if so equipped.
12. Disconnect and plug fuel pump inlet fuel line.
13. Drain crankcase and remove oil filter.
14. Remove bolt attaching transmission oil filler tube to engine block and remove tube.
15. Disconnect muffler inlet pipe from exhaust manifolds.
16. Disconnect muffler inlet pipe at muffler flange and remove inlet pipe.
17. Remove upper inlet pipe mounting stud from right exhaust manifold.
18. Remove nuts and washers attaching engine insulators to No. 1 crossmember.
19. Lower vehicle.
20. E-250—E-350: Install Rotunda Engine Lifting Brackets 014-00312 or equivalent, to front of engine. Connect Engine Lifting Brackets T70P-6000 or equivalent, to lifting sling and raise engine until transmission housing contacts body.

    F-250—F-350: Install lifting sling to lifting eyes on intake manifold and raise engine until transmission housing contacts body.
21. Install wood blocks (2 3/4 inch LH side, 2 inch RH side) between engine insulators and crossmember.
22. Lower engine onto blocks supporting engine.
23. Raise vehicle.
24. Remove flywheel inspection plate.
25. Position fuel pump inlet line at rear of No. 1 crossmember. Remove transmission oil cooler lines, if so equipped, and position out of way.
26. Remove oil pan attaching bolts.
27. Remove oil pump and pick-up tube from engine and lay in oil pan (F-250—F-350 only).
28. Remove oil pan.

    NOTE: Oil pan is gasketless. Pan is sealed to crankcase with silicone gasket material. To remove, insert two screwdrivers through crankcase dowel holes on LH side of crankcase and pry oil pan off (Fig. 88).

    NOTE: Crankshaft may have to be turned to reposition counterweights to aid in removal of oil pan.

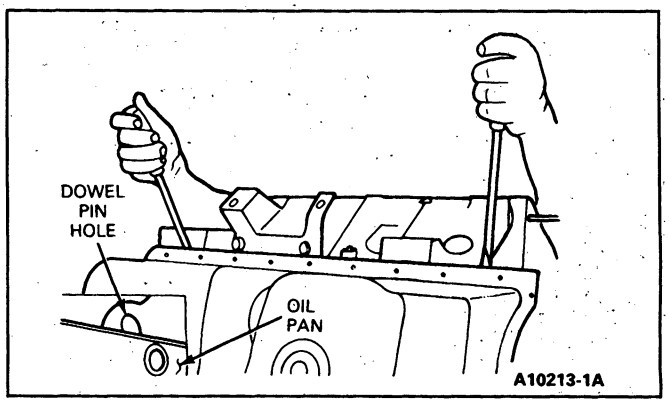


FIG. 88 Oil Pan Removal

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29. Remove oil pump pickup tube from oil pump, if required.

    NOTE: E-250—E-350, oil pump can be removed at this time, if necessary.

Installation

1. Remove old gasket material. Clean mating surfaces of oil pan, engine block and front and rear covers with a suitable solvent and dry thoroughly.
2. Clean mating surfaces of oil pickup tube. Inspect for cracks, and assemble to oil pump with new gasket, if removed. Tighten nuts to specification.

   NOTE: Prime oil pump with recommended engine oil. Rotate pump drive gear to distribute oil within pump body.
3. E-250—E-350, install oil pump and tighten bolts to specification, if removed.
4. Place oil pump and pick-up tube in oil pan.
5. Place oil pan in position on No. 1 crossmember.
6. Install oil pump and pick-up tube and tighten to specifications (F-250—F-350 only).
7. Apply a 3.16mm (1/8 inch) bead of Silicone Rubber Sealant D6AZ-19562-A or equivalent, on side rails of engine block oil pan mating surface, and a 6.35mm (1/4 inch) bead of Silicone Rubber Sealant D6AZ-19562-A or equivalent, on ends of engine oil pan mating surface on front and rear covers, and in mating corners.

   NOTE: When applying Silicone Rubber Sealant always use the bead size specified and join the components within 15 minutes of application. After 15 minutes, sealant begins to "set-up" and sealing effectiveness may be reduced.

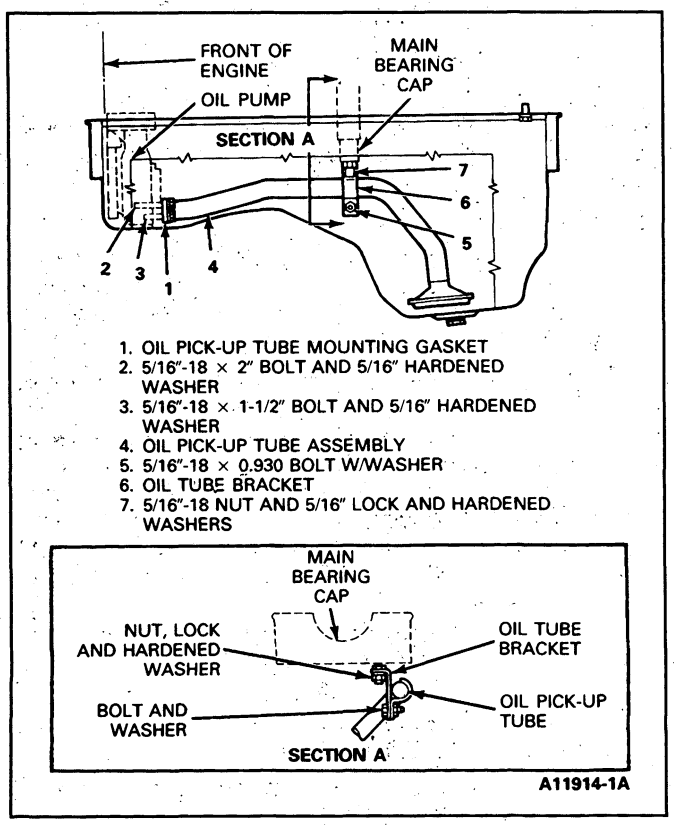


FIG. 89 Oil Pick-Up Tube Installation

8. Install locally fabricated oil pan installation dowels in position (Fig. 90).
9. Position oil pan onto engine and install attaching bolts.
10. Remove oil pan locating dowels and install two remaining oil pan bolts. Tighten all oil pan retaining bolts to specifications.
11. Install flywheel inspection plate and tighten to specifications.
12. Lower vehicle.
13. Raise engine and remove wooden engine support blocks.
14. Lower engine onto No. 1 crossmember and remove lifting sling.
15. Raise vehicle.
16. Install nuts and washers attaching engine insulators to No. 1 crossmember and tighten to specifications.
17. Install upper muffler inlet pipe mounting stud on right exhaust manifold.
18. Position muffler inlet pipe in vehicle and connect muffler inlet pipe to muffler flange, using a new gasket, and tighten to specification.
19. Connect muffler inlet pipe to exhaust manifolds and tighten to specification.
20. Install transmission oil filler tube, using a new O-ring and tighten attaching bolt to specification.
21. Install oil pan drain plug and new oil filter. Tighten to specifications.
22. Connect fuel pump inlet line to fuel pump and tighten to specification.

    NOTE: Make sure fuel line clip is installed in No. 1 crossmember.
23. Connect transmission oil cooler lines, if so equipped, and tighten to specification.
24. Lower vehicle.

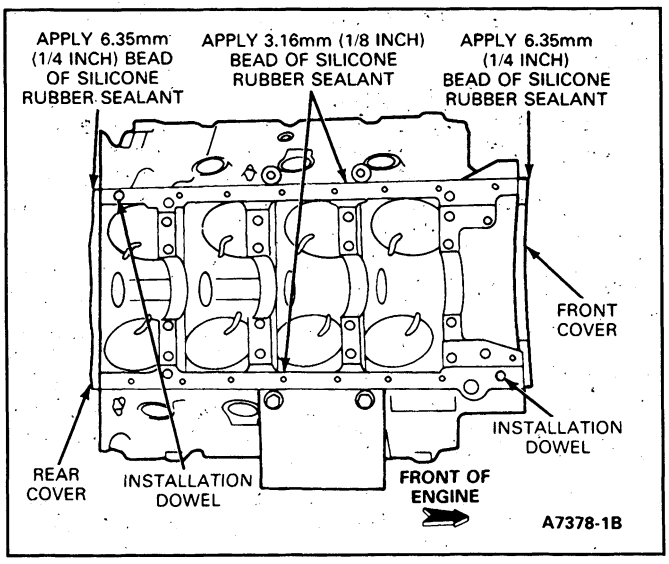


FIG. 90 Applying Silicone Rubber Sealant and Installation Dowels

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25. Connect alternator wiring harness to alternator. Connect wiring harness to top of fuel filter/fuel heater/water separator.
26. Connect power steering return hose to power steering pump.
27. Connect lower radiator hose clamp and tighten to specification.
28. Install radiator fan and clutch assembly using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B or equivalents, and tighten to specification.

    CAUTION: LH thread. Install by turning nut counterclockwise.
29. Remove intake manifold cover, and install air cleaner. Tighten to specifications.
30. Install engine oil and transmission oil dipsticks.
31. Refill and bleed cooling system. Refer to Section 27-02, Cooling System Service.
32. Fill Crankcase with specified quantity, and viscosity of engine oil.
33. Connect ground cables to both batteries.
34. Run engine and check for oil, fuel and coolant leaks.
35. Check power steering fluid and add, if necessary.

Overhaul

NOTE: Engine must be removed from chassis for piston or crankshaft service.

NOTE: Crankshaft and piston cooling jets must be removed prior to cylinder, or piston/ring service. Piston cooling jets could be damaged by cylinder deglazing or honing operations.

NOTE: When assembling the engine during overhaul it is important to prelubricate the running parts with clean engine oil to assure initial lubrication when the engine is started. To further assure complete initial lubrication, the engine lubricating system should be pressure primed or charged with oil. Priming the lubricating system will minimize the possibility of scuffing or heat build-up during initial engine operation, which could lead to immediate or low mileage failure.

Cylinder Assembly—6009

Disassembly

1. Mount the old engine on a work stand using Rotunda Engine Stand Mounting Adapters 014-00306 or equivalent, and remove all parts not furnished with new cylinder assembly. Follow applicable Removal and Installation procedures in this Section.
2. Remove four cylinder head locating dowels and block drain plugs.
3. Remove old cylinder assembly from work stand.

Assembly

1. Clean gasket and seal surfaces of all serviceable parts and assemblies with a suitable solvent and dry thoroughly.
2. Position new cylinder assembly on a work stand and install cylinder head locating dowels and block drain plugs.
3. Transfer all serviceable parts removed from original cylinder assembly, following procedures described under Removal and Installation in this Section.
4. Check all assembly clearances. Ensure that clearances are in accordance with Specifications listed at end of this Section. Service as necessary.

Cylinder Block—6010

Before replacing a cylinder block, determine if it is repairable. If so, make the necessary repairs, following procedures outlined.

Disassembly

1. Mount old engine in a work stand using Rotunda Engine Stand Mounting Adapters 014-00306 or equivalent. Completely disassemble engine following procedures described under Removal and Installation in this Section.
2. Ridge-ream cylinder bores before removing piston assemblies.
3. Remove cylinder head locating dowels and block drain plugs.

Assembly

1. Clean gasket and seal surfaces of all serviceable parts and assemblies with a suitable solvent and dry thoroughly.
2. Position new cylinder block in a work stand and install cylinder head locating dowels and block drain plugs.
3. Transfer all serviceable parts removed from original cylinder block following procedures described under Removal and Installation in this Section.
4. Check all assembly clearances. Ensure that clearances are in accordance with Specifications at end of this Section. Service as necessary.

Pistons and Connecting Rods

NOTE: Do not use a power wrench for removing or installing connecting rod bolts, nuts and washers. Power wrench usage will cause seizure of connecting rod bolt or nut threads.

Removal

1. With engine removed from vehicle and placed on an engine stand as outlined under Cylinder Assembly, remove injection pump, intake manifold, cylinder heads, oil pan, and oil pump as outlined.
2. Remove any ridges and/or deposits from upper end of cylinder bores as follows:
   a. Turn crankshaft until piston to be removed is at the bottom of its travel. Place a cloth on piston head to collect cuttings. Remove any ridge and/or deposits from upper end of cylinder bores. Remove cylinder ridge with a ridge cutter. Follow instructions furnished by tool manufacturer.

      CAUTION: Never cut into ring travel area. Maximum cylinder ridge cutter depth is 0.79mm (0.031 inch).
3. Mark all connecting rods and caps to permit installation into original positions.
4. Turn crankshaft until connecting rod being removed is down (BDC).
5. Remove connecting rod nuts and cap.

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6. Install Connecting Rod Installation Guides D83T-6136-A or equivalent onto connecting rod bolts.
7. Push connecting rod and piston assembly out top of cylinder with handle end of a hammer. **Avoid damage to cooling jets, crankshaft journal or cylinder wall when removing piston and rod.**
8. Remove bearing inserts from connecting rod and cap, if required.
9. Install cap onto connecting rod from which it was removed.

Installation

1. If new piston rings are to be installed, remove cylinder wall glaze. Follow instructions of the tool manufacturer. Cylinder bores must be cleaned with a soap and water solution after deglazing or honing. Dry and oil cylinder walls immediately after cleaning as outlined. Use proper size ring installer tool.
2. Oil piston rings, pistons, and cylinder walls with specified engine oil. **Be sure to install pistons in same cylinders from which they were removed, or to which they were fitted. Connecting rods and bearing caps must be numbered 1, 3, 5, 7, in left bank, beginning at front of engine. The numbers on connecting rod and bearing cap must be on same side when installed in cylinder bore. If a connecting rod is ever transposed from one block or cylinder to another, new bearings should be fitted and connecting rod should be numbered to correspond with a new cylinder number.**
3. Make sure ring gaps (oil ring spacer-A, oil ring-B, compression ring-C) are properly spaced around circumference of piston (Fig. 92).
4. Turn crankshaft throw to position shown in Fig. 93.
5. Install connecting rod upper bearing. Install Connecting Rod Installation Guides D83T-6136-A or equivalent. Before installing, verify that large chamfer on connecting rod faces crankshaft check (facing toward front on engine on right bank rods, and toward rear of engine on left bank rods). Install Piston Ring Compressor D81L-6002-C or equivalent, onto piston and push piston in with a hammer handle until it is slightly below top of cylinder (Fig. 94). Guide connecting rods to avoid damaging cooling jets and crankshaft journals. **Install piston with arrow and eyebrows on piston head toward camshaft. (Fig. 95).**
6. Push piston downward until connecting rod bearing seats on crankshaft journal. Remove protective sleeves and install lower bearing and cap.
7. Check clearance of each bearing and connecting rod side clearance following procedure described under Main and Connecting Rod Bearings.
8. After bearings have been fitted, apply a light coat of specified engine oil to journals and bearings.
9. Install connecting rod cap and bearing. Tighten connecting rod nuts alternately to 52 N·m (38 ft-lb). Tighten nuts to 69 N·m (51 ft-lb).

   NOTE: Lightly coat bolt threads with oil before installing.

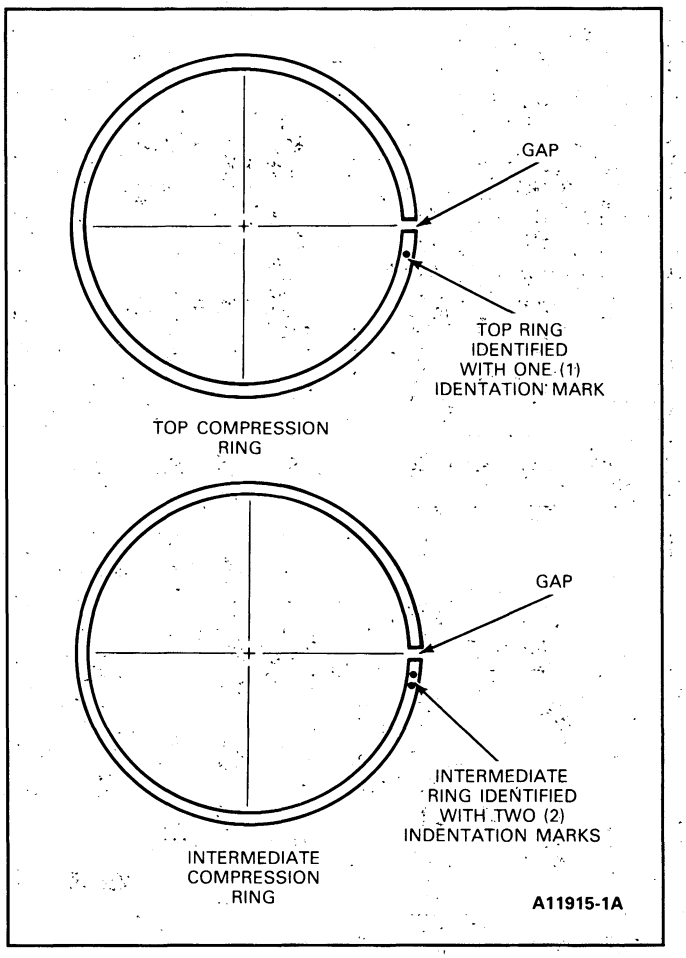


FIG. 91 Ring Identification

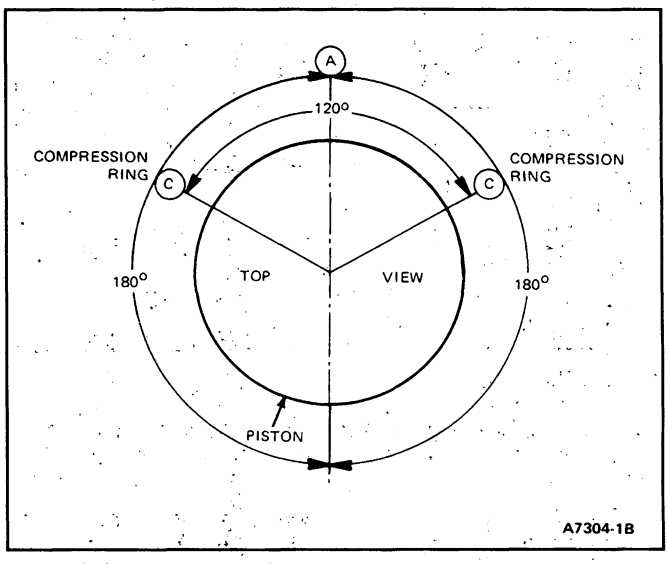


FIG. 92 Piston Ring Spacing

Crankshaft

Removal

1. With engine removed from vehicle and placed on an engine stand as outlined under Cylinder Assembly remove injection pump and adapter, engine front and rear covers, oil pan, oil pump and pick up, as outlined.

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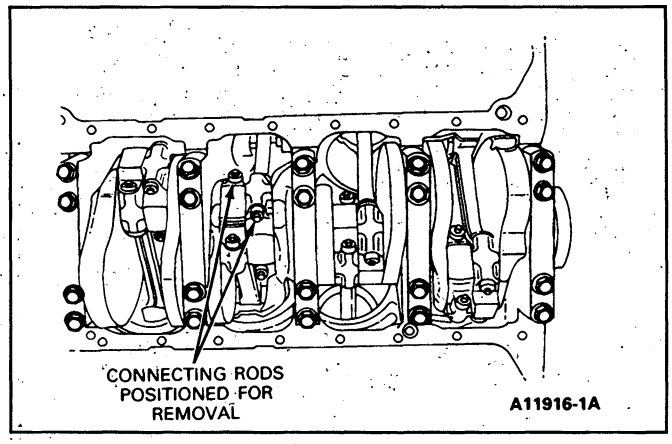


FIG. 93 Positioning Connector Rods for Removal

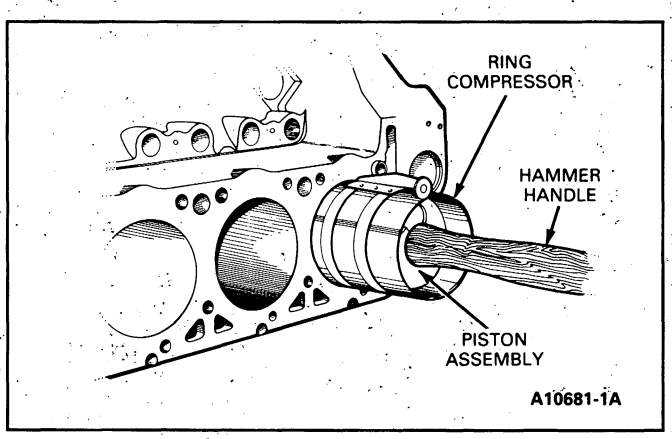


FIG. 94 Installing Piston—Typical

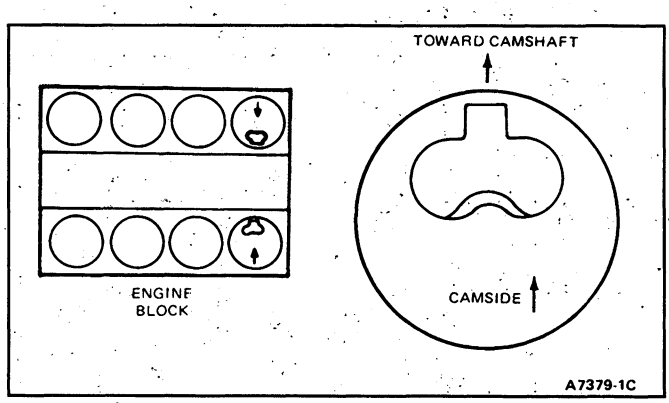


FIG. 95 Piston Orientation

2. Mark all bearing caps (main and connecting rod) to permit installation into their original locations.

3. Turn crankshaft until connecting rod from which cap is being removed is down (BDC), and remove bearing cap. Install Connecting Rod Installation Guides D83T-6136-A or equivalent, and push connecting rod and piston assembly up into cylinder. Remove rod and piston from cylinder. Remove guides and install bearing cap. Repeat this procedure until all connecting rods are removed.

CAUTION: Use care to avoid damage to crankshaft journal, cooling jets and cylinder wall when moving piston assembly.

4. Remove main bearing caps. Main bearing caps are numbered from front of engine.

5. Install Engine Lifting Brackets T70P-6000 or equivalent, to crankshaft and carefully lift crankshaft out of block so that thrust bearing surfaces are not damaged. **Handle crankshaft with care to avoid possible fracture or damage to finished surfaces. (Refer to Cleaning and Inspection.**

Installation

1. Remove main bearing inserts from block and bearing caps.
2. Clean mating surfaces of block and main bearing caps.
3. Remove connecting rod bearing inserts from connecting rods and caps.
4. If crankshaft main bearing journals have been refinished to a definite undersize, install correct undersize bearings. Ensure bearing inserts and bearing bores are clean. Foreign material under inserts will distort bearings and cause failure.
5. Place upper main bearing inserts with tangs fitting in slots, and oil holes into position in bores. Do not install thrust bearing (No. 3 main bearing) at this time.
6. Install lower main bearing inserts into bearing caps.
7. Carefully lower crankshaft into place. **Handle crankshaft with care to avoid possible fracture or damage to finished surfaces. If necessary refer to Cleaning and Inspection.**
8. Remove lifting eyes.
9. Install upper No. 3 main bearing (thrust flanges and oil hole) by rolling main bearing into saddle.
10. Check clearance of each main bearing following procedure under Fitting Main and Connecting Rod Bearings.
11. Apply specified engine oil to journals and bearings.
12. Install all bearing caps, except thrust bearing cap (No. 3 bearing). **Be sure that main bearing caps are installed in their original locations.** Tighten bearing cap bolts to specification.
13. Install thrust bearing cap with bolts finger-tight.
14. Pry crankshaft forward against thrust surface of upper half of bearing (Fig. 96).
15. Hold crankshaft forward and pry thrust bearing cap to rear. This will align thrust surfaces of both halves of bearing.
16. Retain forward pressure on crankshaft. Tighten cap bolts to specification.
17. Force crankshaft toward rear of engine.
18. Check crankshaft end play as outlined.

Camshaft

Removal

1. Remove engine from vehicle as outlined.
2. With engine placed on an engine stand as outlined under Cylinder Assembly, remove injection pump and adapter, intake manifold and tappets, engine front cover and fuel supply pump as outlined.

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3. Remove camshaft drive gear, fuel supply pump cam, spacer and thrust plate from the camshaft as outlined.
4. Carefully remove camshaft.

CAUTION: Use care to avoid damaging camshaft bearings.

Installation

Coat camshaft lobes with Multi-Purpose Grease D0AZ-19584-AA or equivalent, and lubricate journals with specified engine oil before installation.

1. Oil camshaft journals and apply Multi- Purpose Grease D0AZ-19584-AA or equivalent, to lobes. Carefully slide camshaft through bearings. If tools are available, a handle may be fabricated for easier installation of camshaft by connecting the Puller Screw Extension from Camshaft Bearing Set T65L-6250-A into Camshaft Installation Adapter D83T-6250-A or equivalent. This assembly is then connected onto the end of the camshaft prior to installation. Remove the handle assembly when camshaft is properly seated in the bearings. Install new camshaft thrust plate onto cylinder block and tighten to specification.
2. Install spacer and fuel pump cam against camshaft thrust flange using Crank/Cam Gear and Damper Replacer T83T-6316-B or equivalent.
3. Install camshaft drive gear against fuel pump cam, aligning timing mark with timing mark on crankshaft drivegear using Crank/Cam Gear and Damper Replacer T83T-6316-B or equivalent.
4. Install camshaft allen screw and tighten to 20 N·m (15 ft-lb).
5. Install fuel supply pump, as outlined.
6. Install new crankshaft oil seal in engine front cover as outlined.
7. Install engine front cover as outlined.
8. Install water pump as outlined.
9. Install injection pump adapter as outlined.
10. Lubricate tappets and bores with specified engine oil and install tappets in their original positions.
11. Install tappet guides.
12. Install tappet guide retainer and tighten to specification.
13. Position push rods, copper colored ends toward rocker arms, into their respective tappets making sure they are seated fully in push rod seats.
14. Install rocker arms and valve covers with new gaskets as outlined.
15. Install intake manifold as outlined.
16. Install injection pump as outlined.
17. Install engine into vehicle as outlined.

Camshaft Bearings

The bearings are interchangeable from one bore to another except for the front bearing which is wider than the others.

Removal

1. Remove engine from vehicle as outlined. Mount engine stand using Rotunda Engine Stand Mounting Adapter 014-00306 or equivalent.
2. Remove camshaft, flywheel and crankshaft, following appropriate procedures in this Section. Push pistons to top of cylinders.

CAUTION: Use care when pushing pistons to top of cylinders to prevent damage to piston cooling jets. Use Connecting Rod Installation Guides D83T-6136-A or equivalent, protect connecting rod bolts.

3. Using Camshaft Bearing Set T65L-6250-A or equivalent, select proper size expanding collet and backup nut and assemble on expanding mandrel. With expanding collet collapsed, install collet assembly in camshaft bearing, and tighten back-up nut on expanding mandrel until collet fits camshaft bearing (Fig. 97).
4. Assemble puller screw and extension, if necessary, as shown and install on expanding mandrel. Wrap a cloth around threads of puller screw to protect front bearing or journal. Tighten pulling nut against thrust bearing and pulling plate to remove camshaft bearing. Be sure to hold wrench on end of puller screw to prevent it from turning.

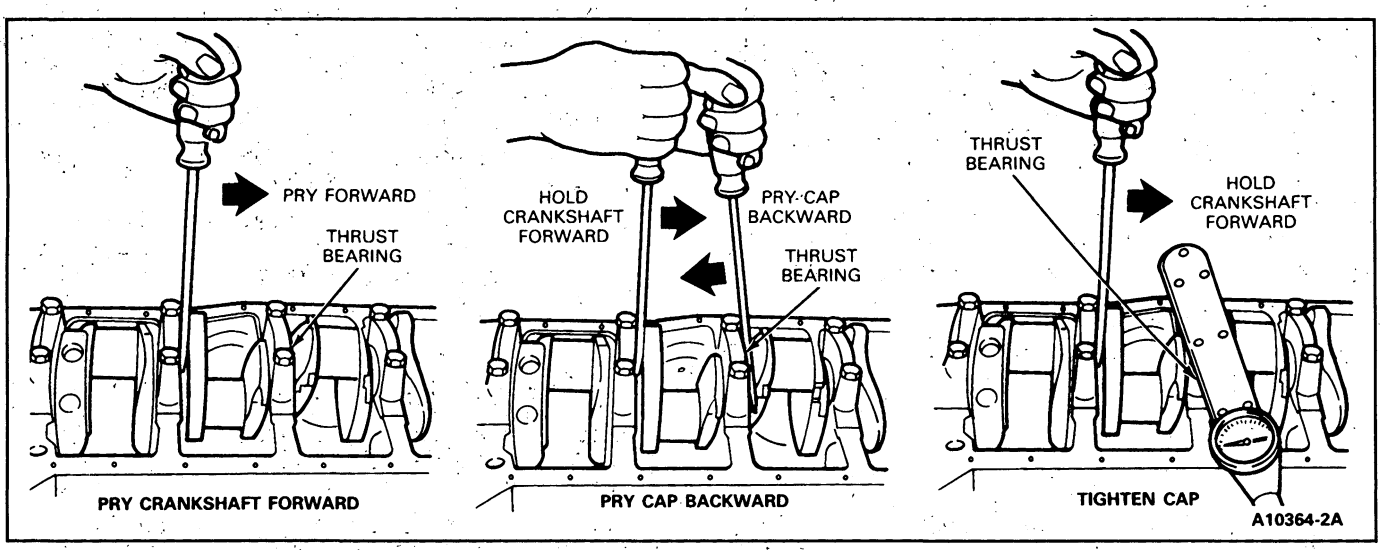


FIG. 96 Aligning Thrust Bearing Cap—Typical

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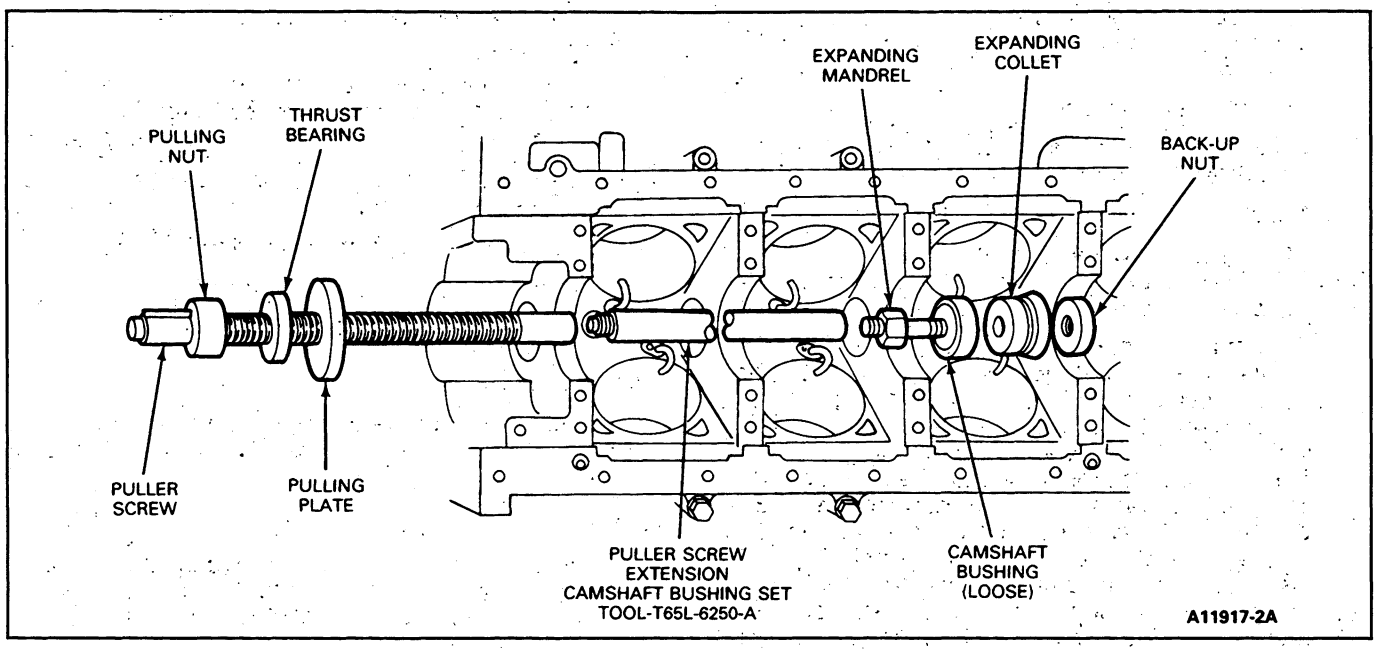


FIG. 97 Camshaft Bearing Replacement—Typical

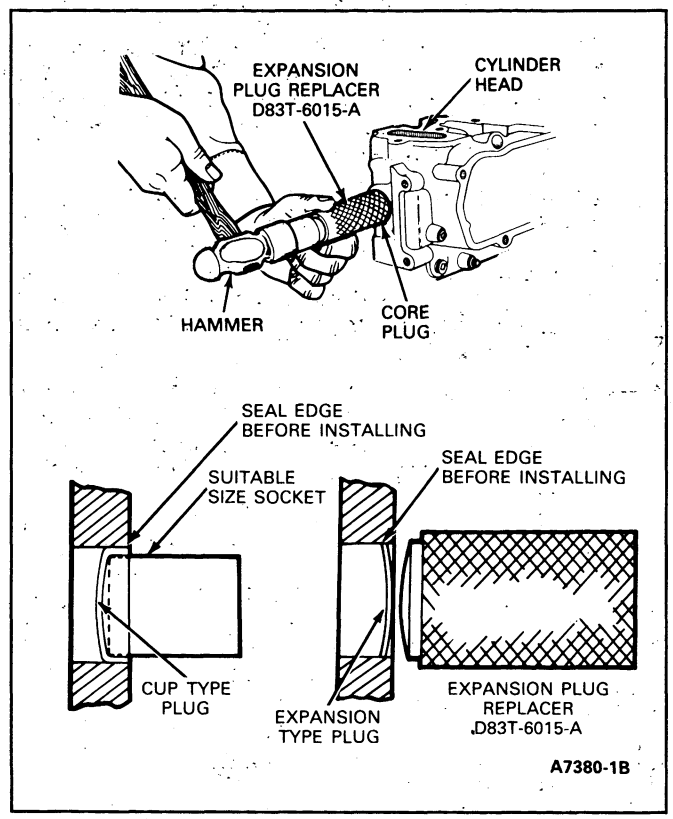


FIG. 98 Typical Core Plugs and Installation Tool

5. Repeat procedure for each bearing. To remove front bearing, install puller screw from rear of cylinder block.

Installation

1. Position new bearings at bearing bores with oil holes aligned, and press in place with Camshaft Bearing Set T65L-6250-A or equivalent shown in Fig. 97. Be sure to center pulling plate and puller screw to avoid damage to bearing. **Failure to use correct expanding collet can cause severe bearing damage. Be sure front bearing is installed the specified distance below front face of cylinder block.**
2. Install camshaft, crankshaft, flywheel and related parts, as outlined. It is not necessary to check connecting and main bearing clearances as a part of Camshaft Bearing Replacement.
3. Install engine into vehicle as outlined.

Core Plugs

Removal and Installation

To remove a large core plug, drill a 12.70mm (1/2 inch) hole in the center of plug and remove with Impact Slide Hammer T59L-100-B, T50T-100-A or equivalent, or pry it out with a large drift punch. On a small core plug, drill a 6.35mm (1/4-inch) hole in center of plug and pry it out with a small pin punch. Clean and inspect plug bore.

Prior to installing a core plug, plug bore should be inspected for any damage that would interfere with proper sealing of plug. If the bore is damaged it will be necessary to true surface by boring for next specified oversized plug.

Oversize (OS) plugs are identified by OS stamped in flat located on cup side of plug.

Coat plug and/or bore lightly with Perfect Seal Sealing Compound B5A-19554-A or equivalent, and install it following procedure for cup type or expansion type below:

Cup-Type

Cup-type core plugs (Fig. 98) are installed with flanged edge outward. Maximum diameter of plug is located at outer edge of flange. Flange on cup-type plugs flares outward with largest diameter at outer (sealing) edge.

CAUTION: It is important to pull plug sealing edge into machined bore by using a properly sized socket. Under no circumstances is plug to be driven

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into bore using a tool that contacts flange. This method will damage sealing edge and will result in leakage and/or plug blow out.

Flanged (trailing) edge must be below chamfered edge of bore to effectively seal plugged bore.

If core plug replacing tool has a depth seating surface, do not seat tool against a non-machined (casting) surface.

Expansion-Type

Expansion-type core plugs (Fig. 98) are installed with (dished) edge inward flush with bottom edge of chamfer.

Coat edges of plug with a suitable non-hardening sealing compound and install using Expansion Plug Replacer D83T-6015-A or equivalent, and hammer. When installed, trailing (maximum) diameter must be below edge of bore to effectively seal bore.

NOTE: For in-vehicle repair, use commercially available closure plugs until engine is removed for overhaul.

Cylinder Head

New cylinder head assemblies are interchangeable from one cylinder bank to another. Used cylinder heads should be installed into their original positions using new gaskets. Cylinder head gaskets are interchangeable.

1. Clean gasket surface. Remove all burrs or scratches with an oil stone.
2. Check for warpage or cracks. Replace head if warped or cracked.

   NOTE: Cylinder heads are not to be resurfaced.

Replacing Valve Guides

Excessive guide clearance prevents adequate cooling of valve through guide and allows valve to tilt or tip which may cause valve breakage at high engine speed. These conditions prevent good seating and promote leakage past valve face. If valve guides are either larger than specified or damaged, use Valve Guide Tools D83T-6085-A or equivalent, and follow manufacturer's instructions. Install as follows:

1. Drill out valve guide.
2. Ream drilled guide bore for recommended insert sleeve.

   NOTE: Before installing inserts they should be thoroughly chilled with dry ice or other means to facilitate their installation in the cylinder head.
3. Chill repair insert in dry ice. Carefully press insert into bore (Fig. 99).

   NOTE: When installing repair insert, be careful not to burr ID of insert.
4. Finish insert with recommended size reamers to specified valve guide diameter. Always re-face valve seat after valve guide has been reamed, and use suitable scraper to break sharp corner (ID) at top of valve guide.

Valve Seats

Prior to seat reconditioning, clean seats and inspect for cracks, burning or other damage. Inspect exhaust seat inserts for looseness.

Removal—Exhaust Seats

1. Use Exhaust Valve Seat Remover/Replacer D83T-6084-A or equivalent, to remove damaged or loose seats (Fig. 100). Position removal collet into insert and rotate collet nut clockwise to expand collet jaws under lip of seat insert.
2. Rotate top nut clockwise to remove insert.

   NOTE: If an oversize seat insert is required, the cylinder head should be sent out to a qualified machine shop for insert counterbore procedure.

Installation

1. Install valve seat using Exhaust Valve Seat Remover/Replacer D83T-6084-A or equivalent, and a hammer (Fig. 100). Valve seat inserts supplied for service are standard size, .015" oversize and .030" oversize.

Refacing Valve Seats

Refacing of valve seat should be closely coordinated with refacing of valve face so that finished seat and valve face will be concentric and specified interference fit will be maintained. This is important so that valve and seat will have a compression tight fit. Ensure that valve seat grinding wheels are properly dressed.

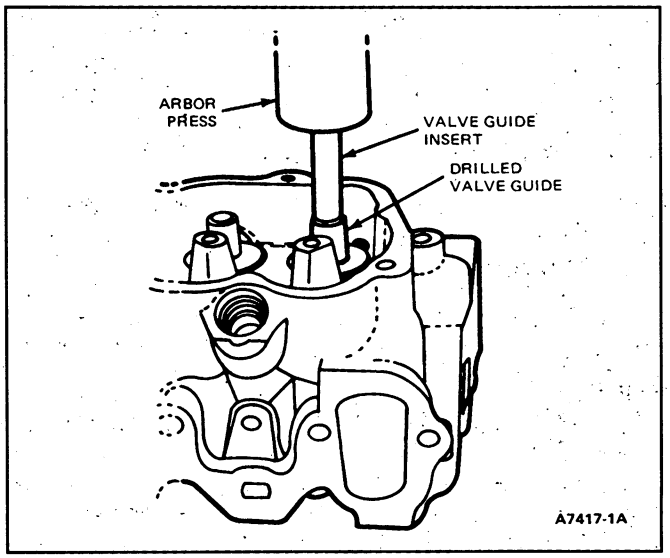


FIG. 99 Installing Valve Guide Insert

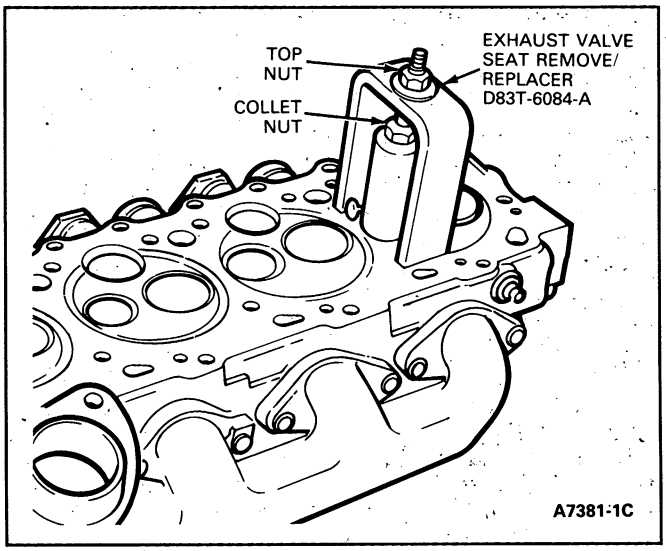


FIG. 100 Exhaust Seat Insert Removal

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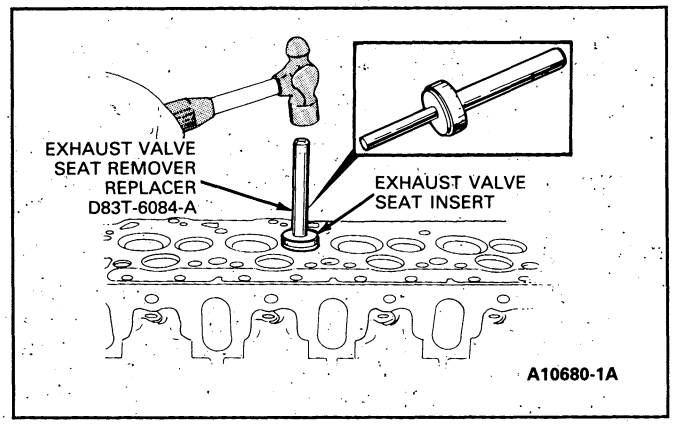


FIG. 101 Installing Exhaust Seat Insert

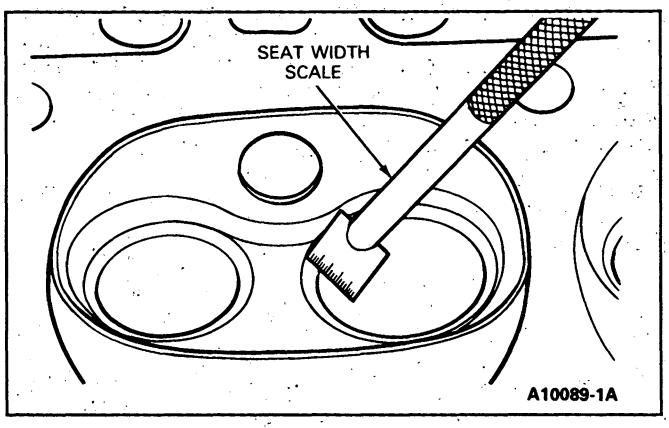


FIG. 102 Checking Valve Seat Width—Typical

Grind valve seats to specification. Remove only enough stock to clean up pits and grooves or to correct valve seat runout. After seat has been refaced, use seat width scale or machinist scale to measure seat width (Fig. 102). Narrow seat, if necessary to bring it within specification. Refer to specifications.

If valve seat width exceeds maximum limit, remove enough stock from top edge and/or bottom edge of seat to reduce width to specification.

Use a 60 degree angle grinding wheel to remove stock from bottom of seats (raise seats) and use a 15 degree angle wheel to remove stock from top of seats (lower seats) (Fig. 103).

Finished valve seat should contact approximate center of valve face. It is good practice to determine where valve seat contacts face. To do this, coat seat with Prussian blue and set valve in place. Rotate valve with light pressure. If blue is transferred to center of valve face, contact is satisfactory. If blue is transferred to top edge of valve face, lower valve seat. If blue is transferred to bottom edge of valve face, raise valve seat. **Fit of valve and seat should never be lapped out with lapping compounds.**

Valves

Inspect valve for evidence of burning, warping,scuffing or bending. Minor pits, grooves, etc., may be removed. Discard valves that are severely damaged, if face runout cannot be corrected by refinishing, or if stem clearance exceeds specifications. Refer to specification.

Discard any worn or damaged valve train parts.

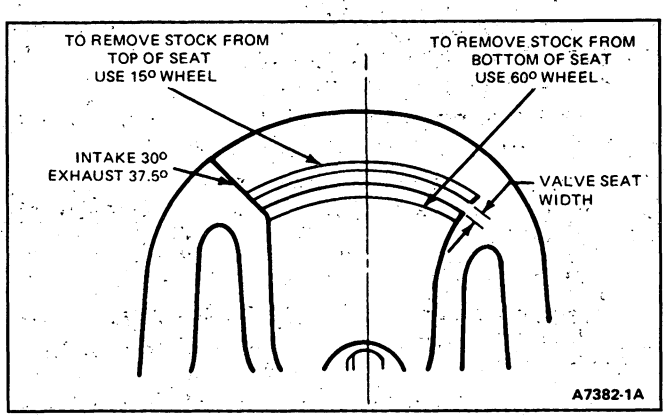


FIG. 103 Refacing Valve Seat

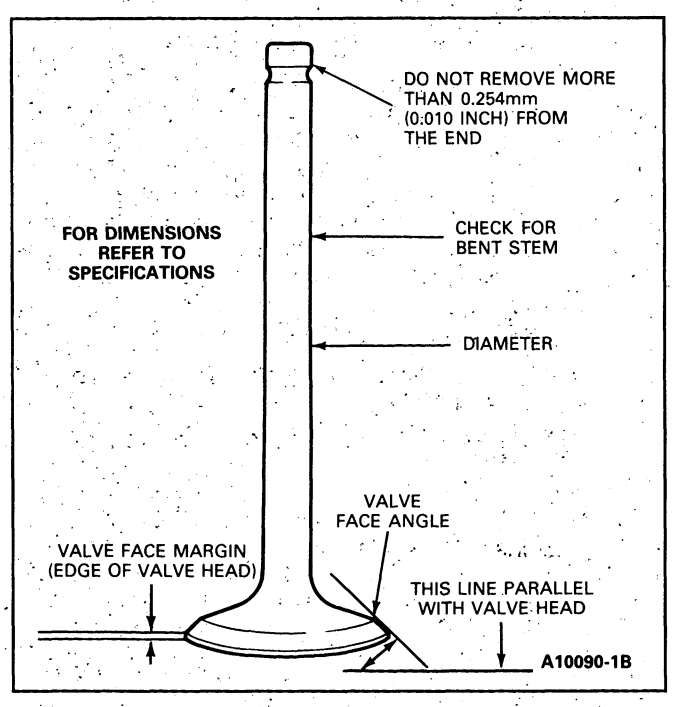


FIG. 104 Critical Valve Dimensions

Refacing Valves

The valve refacing operation should be closely coordinated with valve seat refacing operations so that finished angles of valve face of valve seat will be to specifications and provide a compression tight fit. Be sure that valve grinding wheels are properly dressed.

If valve face runout is excessive and/or to remove pits and grooves, reface valves to specification. Remove only enough stock to correct runout or to clean up pits and grooves. If edge of intake valve head is less than 2.84mm (0.112 inch) thick after grinding (Fig. 104), replace valve as valve will run too hot in engine. If edge of exhaust valve head is less than 1.35mm (0.053 inch) thick after grinding replace valve. **Interference fit of valve and seat should not be lapped out.**

Remove all grooves or score marks from end of valve stem, and chamfer it as necessary. **Do not remove more than 0.254mm (0.010 inch) from end of valve stem.**

If valve and/or valve seat has been refaced, it will be necessary to check clearance between rocker arm pad and valve stem tip with valve train assembly installed in engine.

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Camshaft Repair

Remove light scuffs, scores or nicks from camshaft machined surfaces with smooth oil stone marks.

Crankshaft Repair

Clean all parts with cleaning solvent, dry with compressed air, and inspect bearings for wear and evidence of uneven bearing support. If such evidence is present, examine bearing caps and supporting surfaces or crankcase for high spots and burrs.

Inspect crankshaft journals for scoring, burning and cracking. Measure diameter of each journal using a micrometer. Check dimensions obtained against Specifications. Measure each journal at two points, one at right angles to other, in order to show any evidence of out-of-round. Move micrometer over entire width of journal.

Crankshafts must not be straightened. Even slight straightening with complete absence of cracks will endanger the high strength built into the shaft.

Bearing failures can cause overheating of crankshaft journals and a reduction of hardness. When this occurs, the crankshaft strength may be unacceptably reduced. Whenever bluing is found on the journal or fillet area, the crankshaft must be replaced.

Crankshaft Grinding

An induction-hardened fillet and journal crankshaft can be reground similar to any precision crankshafts. However, these shafts require special treatment when grinding. Before grinding, all crankshafts must be checked for hardness.

Crankshafts should be ground at a qualified machine shop, experienced in grinding induction hardened crankshafts. Crankshafts should be magnifluxed after grinding to insure that there are no surface cracks.

Crankshaft Undersize Grinding Limits

Grinding Limits:

Maximum allowable taper on crankpins (rod journals) and main journals .013mm (.0005 inches) per 25.4mm (1 inch) of length. Crankpins and journals must be polished to 508 Micro-mm (20 Micro-inch) maximum - to 127 Micro-mm (5 Micro-inch) minimum, and must not be over 0.003mm (0.0001 inch) out of round.

The main journal fillet radii should be 3.07 - 3.226mm (.121 - .127 inch) with the crankpins (rod journals) fillet radii held at 3.05mm (.120 inch).

The third main journal controls crankshaft end thrust and provides initial location of crankshaft in relation to crankcase. For this reason the width of the third journal must be 28.766 - 28.841mm (1.1325 - 1.1355 inch).

Fitting Main or Connecting Rod Bearings With Plastigage

Fitting Main Bearings.

NOTE: Be sure bearing inserts, bearing bore and mating surfaces are clean. Foreign material under inserts will distort bearing and cause incorrect readings and subsequent bearing failure.

To obtain an accurate reading using Plastigage method of checking, all bearing caps must be in place and tightened to specification.

1. Remove one bearing cap and insert. Leave remaining caps tight while checking fit of bearing.
2. Wipe oil from all contact surfaces such as crankshaft journal, bearing insert, bearing caps, etc.
3. Place piece of Plastigage D81L-6002-B or equivalent, across full width of bearing surface on crankshaft journal (or bearing cap insert) approximately 6.35mm (1/4 inch) off center. Install bearing cap and tighten cap bolt to specification.

   NOTE: Lightly coat bolt threads with oil before installing.

   NOTE: Do not turn crankshaft while making check with plastigage.
4. Remove bearing cap and insert.
5. Do not disturb Plastigage. Using Plastigage envelope, measure widest point of Plastigage (Fig. 105). Reading indicates bearing clearance in thousandths of an inch.
6. If the bearing clearance is not within specifications, crankshaft must be reground and undersize bearings installed.
7. No. 3 crankshaft bearing controls crankshaft and provides initial location of crankshaft in relation to crankcase. Use Dial Indicator with Bracketry Tool—4201-C or equivalent, to check end play as outlined.

Fitting Connecting Rod Bearings

NOTE: Be sure bearing inserts, bearing bore and mating surfaces on connecting rod and cap are clean. Foreign material under inserts will distort bearing and cause incorrect readings and subsequent bearing failure.

1. Remove bearing cap and wipe oil from face of bearing insert and exposed portion of crankshaft journal.
2. Place a piece of Plastigage Tool D81L-6002-B or equivalent, on bearing surface across full width of bearing about 6.35mm (1/4 inch) off center.
3. Install cap and tighten to specification.

   NOTE: Lightly coat bolt threads with oil before installing.

   NOTE: Do not turn crankshaft while plastigage is in place.
4. Remove bearing cap and use Plastigage scale to measure widest point of Plastigage (Fig. 106). Reading indicates bearing clearance in thousandths of an inch.

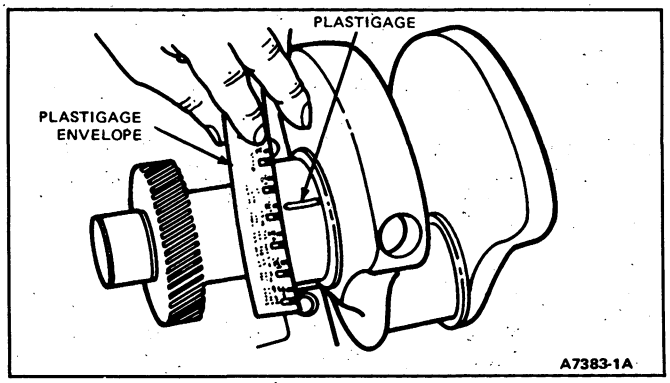


FIG. 105 Checking Main Bearing Clearance

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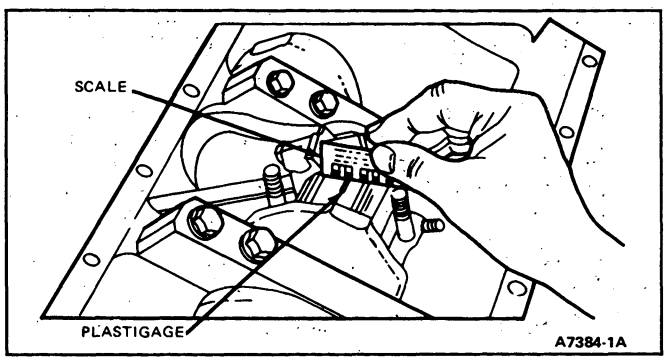


FIG. 106 Checking Connecting Rod Bearing Clearance

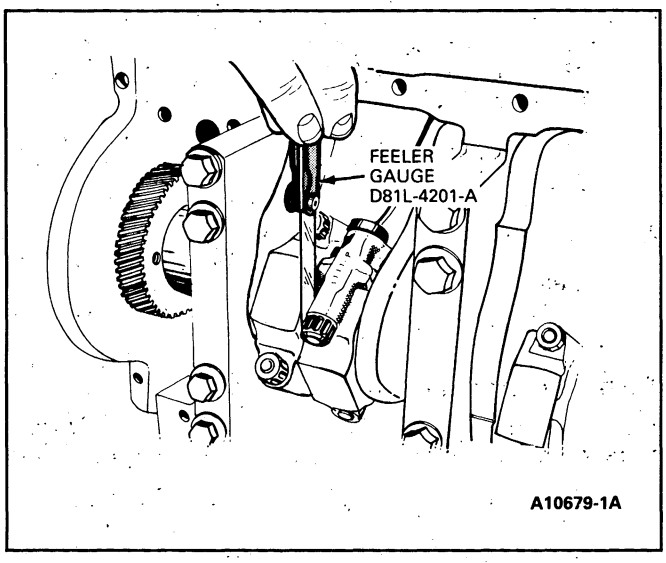


FIG. 107 Checking Connecting Rod End Clearance

5. If bearing clearance is not within specifications, crankshaft must be reground and undersize bearings installed.
6. Check connecting rod end clearance using Feeler Gauge D81L-4201-A or equivalent, as shown in Fig. 107. Excessive clearance may require replacement of rods or shaft. Check should be made to make certain specified running clearance exists. Lack of clearance could indicate damaged rod or rod bearing out of position.

Pistons, Pins and Rings

Fitting Pistons

Pistons are available in standard size or oversize for service. Refer to Ford Parts Master Catalog for available oversize pistons.

Refer to Specifications for standard size piston dimensions.

CAUTION: The size piston selected should be large enough to permit cleaning up the cylinder bore and provide the proper running clearance in the cylinder bore. See Piston in Specifications in this Section.

Measure cylinder bore, (Fig. 108) and select piston to assure proper clearance.

After cylinder bores have been measured and recorded, measure piston diameter to ensure that specified clearance is obtained. Measure piston diameter 31.75mm (1 1/4 inches) below bottom ring land perpendicular to pin center line (Fig. 109). It may be necessary periodically to use another piston (within same grade size) that is either slightly larger, or smaller to achieve specified clearance.

If none can be fitted, refinish cylinder to provide proper clearance for piston.

NOTE: Piston cooling jets must be removed before glaze breaking cylinders. Cooling jets are reusable.

CAUTION: Special "Patch" bolts are used to install piston cooling jets. These bolts are included with new cooling jets. DO NOT use standard bolts.

When piston has been fitted, mark it for assembly in cylinder to which it was fitted.

If taper, out-of-round, and piston-to-cylinder bore clearance conditions are within specified limits, new piston rings will give satisfactory service. **If new rings are to be installed in a used cylinder that has not been refinished, remove cylinder wall glaze (refer to Cylinder Block, Refinishing Cylinder Walls). Clean cylinder bore thoroughly.**

If cylinder bores exceed out-of-round and/or taper specifications, reboring may be required. Such cylinder bore reconditioning will require the use of oversize service pistons. In addition to the standard size service piston .254mm (.01 inch), 508mm (.02 inch) .762mm (.03 inch) oversize pistons are available. Verify piston size by measuring skirt diameter.

1. Calculate size of piston to be used by checking cylinder bore. Follow procedures described under Cleaning and Inspection.

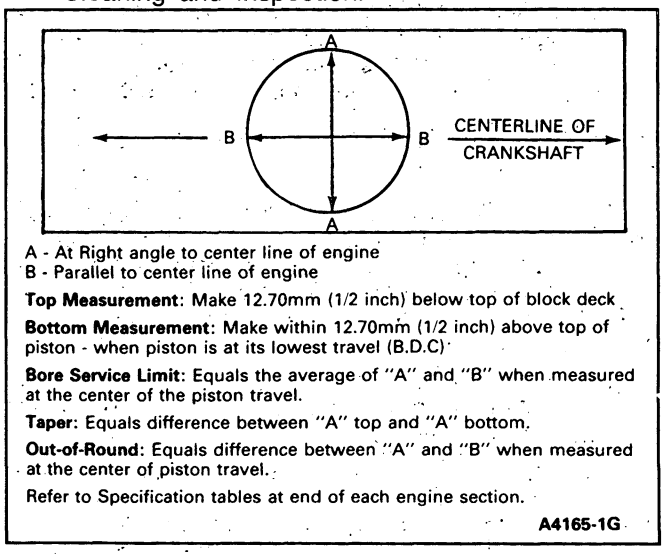


FIG. 108 Cylinder Bore Measurement

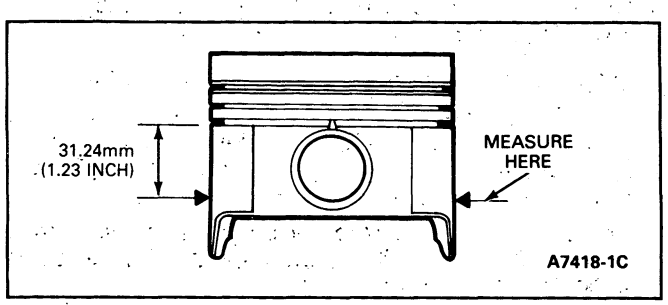


FIG. 109 Piston Diameter

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2. Select proper size piston to provide desired clearance (refer to Specifications).
3. Make sure piston and cylinder block are at room temperature 21°C (70°F). After any refinishing and washing operation allow cylinder bore to cool, and make sure piston and bore are clean and dry before piston fit is checked.

Fitting Piston Pins

Inspect and measure piston pins for wear. If piston pins show signs of wear, corrosion or etching replace with new pins.

Check ID of connecting rod and piston pin bores. Replace any connecting rod or piston that is not within specifications. Piston assemblies furnished for service replacement are complete with new piston pins.

Fitting Rings

NOTE: A worn ring cannot always be detected by visual inspection. Therefore, whenever a piston is removed from a cylinder, it is recommended that the piston rings be replaced.

1. Select proper ring set for cylinder bore size.
2. Position ring in cylinder bore in which it is going to be used.
3. Push ring down into bore area where normal ring wear is not encountered.
4. Use head of a piston to position ring in bore so that ring is square with cylinder wall. Use caution to avoid damage to ring or cylinder bore.
5. Measure gap between ends of ring with Feeler Gauge D81L-4201-A or equivalent, (Fig. 110). If ring gap is less or greater than specifications, try another ring set listed under Specifications.
6. Check compression ring side clearance using Feeler Gauge D81L-4201-A or equivalent, inserted between ring and its lower land (Fig. 111). Gauge should slide freely around entire ring circumference without binding. Any wear that occurs will form a step at inner portion of lower land. If lower lands have high steps, piston should be replaced.

Piston and Connection Rod Assembly

Disassembly

1. Remove bearing inserts from connecting rod and cap.
2. Mark pistons to assure assembly with same rod and installation into cylinders from which they were removed.
3. To disassemble connecting rod from piston and piston pin assembly, remove piston pin retainers from each end of pin using snap ring pliers.
4. After placing piston in vise, drive pin from assembly using drift and hammer. (Fig. 112) or equivalent, or brass drift and plastic tipped hammer.
5. After pin is removed, separate piston from connecting rod. Remove all old rings from piston. Clean and inspect components as described in this Section.

Assembly

1. To assemble piston to connecting rod, position rod into piston so that connecting rod weight pad and large chamfered side is located against crankshaft

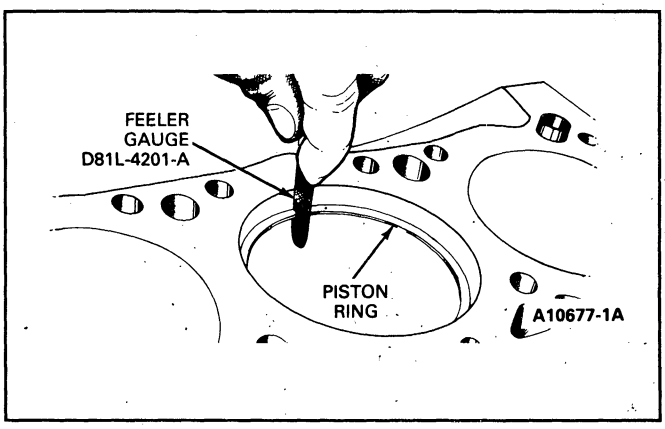


FIG. 110 Checking Piston Ring Gap

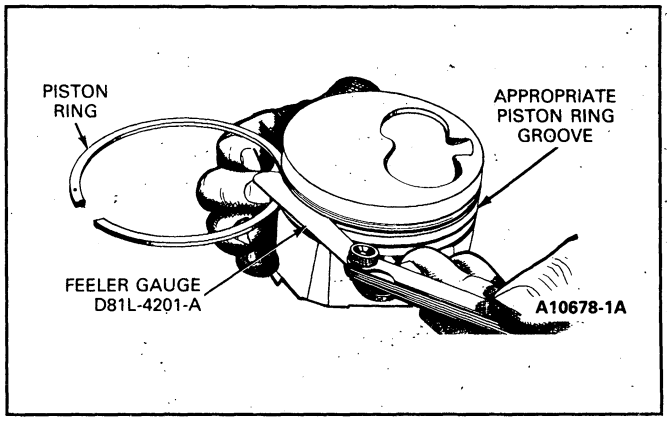


FIG. 111 Checking Piston Ring Side Clearance

face and top of piston's arrow faces camside (Fig. 113).

2. Lubricate piston pin with specified engine oil. Align rod bore and piston bore and insert piston pin. Push piston pin with thumb and install retainer snap rings. Ensure that retainer rings seat fully in their grooves.
3. After checking piston ring end gap as outlined assemble rings onto pistons to which they were fitted by using a suitable ring expander tool. This type of tool is recommended to avoid over expansion of rings, and also to expand rings to a true circle to avoid distortion (Fig. 114).
4. Check ring side clearance as outlined.

Cylinder Block

Refinishing Cylinder Walls

1. To refinish cylinder walls, obtain a "flexhone" for a four (4) inch bore engine with a 120 gift rating (no color code). This type of hone Looks like a wire brush with carbide balls on the ends of the bristles. also, get a full 12-ounce container of Ford "Rust Penetrant and Inhibitor" (D7AZ-19A501-A). This spray contains colloidal graphite and has a blackappearance. Get an electric, or air-powered, drill motor with adjustable speed. A speed of about 100 RPM is required. If this speed is not available. **REPAIR WILL NOT BE SUCCESSFUL.**

Note: It is NOT necessary to remove cranksjaft or piston walls, however, it is good practice to oil the rod journals and wrap them in a shop towel with tape.

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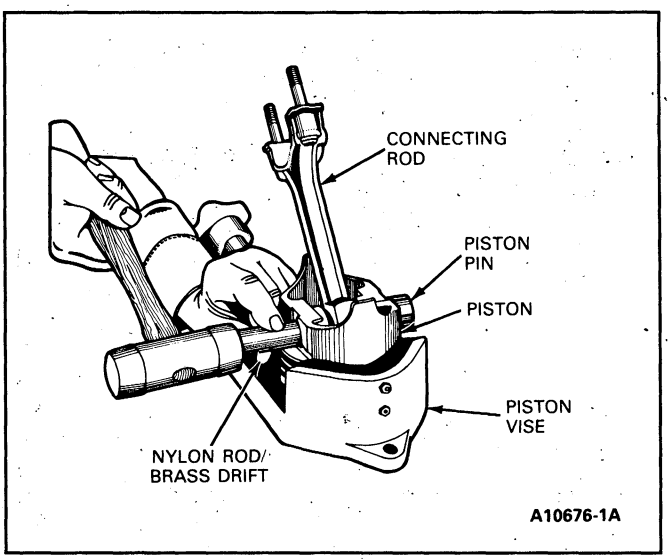


FIG. 112 Removing Piston Pin

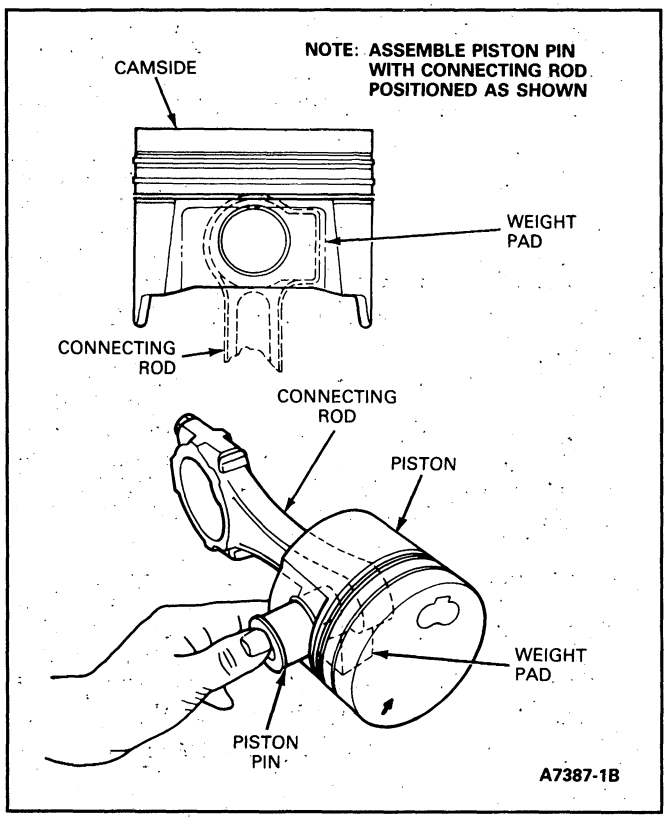


FIG. 113 Piston and Connection Rod Assembly

2. Spray cylinder wall and hone cylinder wall for about three seconds while stroking up and down twice a second. Remove the hone (ALWAYS REMOVE WITH HONE ROTATING), and wipe a portion of cylinder wall. Inspect the crosshatch pattern comparing it to the neighboring (untouched) cylinder. The crosshatch angle should be 120 to 135 degrees.

NOTE: Comparison with a "virgin" bore is the best check, provided the engine has not been repaired before. If the pattern is "flatter" than called for, increase stroke speed or slow down rotation speed. The hone will not damage the piston cooling jet and that

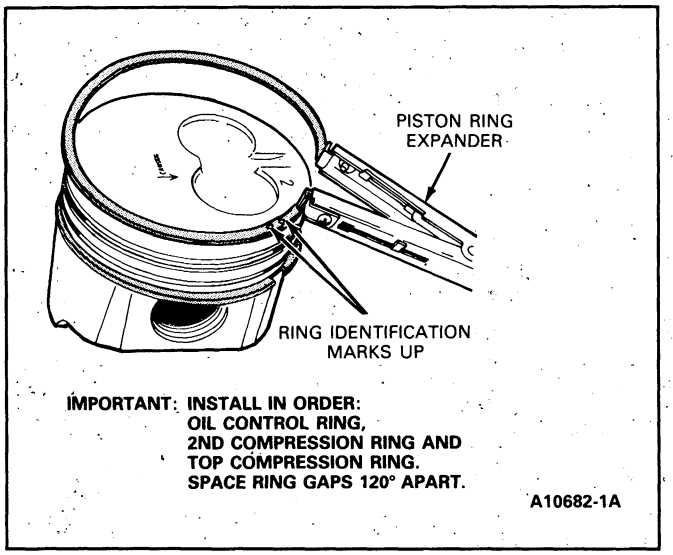


FIG. 114 Installing Piston Ring Using Suitable Piston Ring Expander Tool

honing to the very bottom of the cylinder is not required as the piston ring travel stops well short of the bottom of the bore. The hone must be partly removed from the block ar the top of each stroke.

Continue honing the cylinder (after adjusting your technique to get required 120 to 135 degrees crosshatch) for between 10 to 15 seconds, while an assistant continuously sprays the graphite spray at the cylinder well. Do not spend more than 15 seconds (25 strokes) per bore. Wipe cylinder bore clean and inspect. The bore should have a satin-like sheen with a clearly identified crosshatch pattern of 120 to 135 degrees. Compare with a virgin bore to confirm correct angel. Repeat for remaining cylinders.

3. Wash all cylinders with mild soap and water (like dish washing solution). Air dry with shop air and IMMEDIATELY oil cylinder walls to prevent corrosion.

Repairing Engine Casting Holes and Porosities

Porosity or sand hole(s) resulting in oil seepage or leakage can occur with modern casting processes. When diagnosing oil leaks, perform a complete inspection of engine and transmission. If leak is attributed to porous condition of cylinder block or sand hole(s), repairs can be made with Metallic Plastic C6AZ-19554-A or an equivalent metallic plastic. **Do not repair cracks with this material. Repairs with this metallic plastic must be confined to those cast iron engine component surfaces (Fig. 115) where inner wall surface is not exposed to engine coolant pressure or oil pressure.** For example:

a. Cylinder block surfaces extending along length of the block, upward from the oil pan rail to cylinder water jacket but not including machined areas.

b. Lower rear face of cylinder block.

c. Cylinder head, along rocker arm cover gasket surface.

The following procedures should be used to repair porous areas or sand holes in cast iron:

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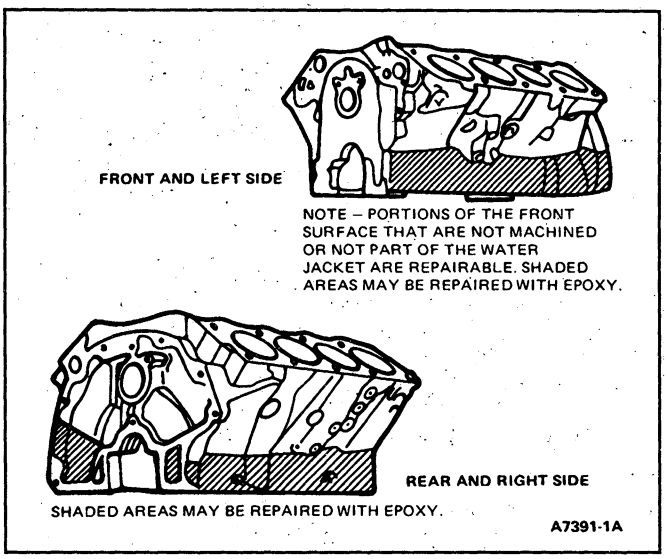


FIG. 115 Typical Cast Iron Cylinder Block Areas—Typical

1. Clean surface to be repaired by grinding or rotary filing to a clean bright metal surface. Chamfer or undercut hole or porosity to a depth greater than rest of the cleaned surface. Solid metal must surround hole. Openings larger than 6.35mm (1/4 inch) should not be repaired using metallic plastic. Openings in excess of 6.35mm (1/4 inch) can be drilled, tapped and plugged using common tools. Clean repair area thoroughly. Metallic plastic will not stick to a dirty or oily surface.
2. Mix Epoxy Resin base and hardener as directed on container. Stir thoroughly until uniformly mixed.
3. Apply repair mixture with a suitable clean tool (putty knife, wood spoon, etc.) forcing metallic plastic into hole or porosity.
4. Allow mixture to harden. This can be accomplished by two methods; heat cure with a 250 watt lamp placed 0.254mm (10 inches) from repaired surface, or air dry from 10-12 hours at temperatures above 10°C (50°F).
5. Sand or grind the repaired area to blend with general contour of surrounding surface.
6. Paint surface to match rest of block.

CLEANING AND INSPECTION

The following cleaning and inspection procedures apply to complete engine overhaul; therefore, for partial engine overhaul or parts replacement, follow applicable component cleaning or inspection procedures.

Crankcase Depression Regulator (CDR)

Refer to Truck Pre-Delivery, Maintenance and Lubrication Manual for the correct mileage interval for maintenance. Service following procedures described in this Section.

Valve Rocker Arm Assembly

Cleaning

Clean all parts thoroughly

Inspection

Inspect pad at valve end of rocker arms for indications of scuffing or abnormal wear. If pad if grooved, replace rocker arm. **Do not attempt to true this surface by grinding.** Check fulcrum and spherical pushrod seats for excessive wear, cracks, nicks or burrs. Inspect fulcrum seat of rocker arm post for excessive wear.

Push Rods

Cleaning

Clean all push rods in a suitable solvent. Blow out oil passage with compressed air.

Inspection

Check ends of push rods for nicks, grooves, roughness or excessive wear.

Push rods can be visually checked for straightens while still installed in engine by rotating them with the valve closed. They also can be checked with a Dial Indicator D78P-4201-G or equivalent (Fig. 116).

Cylinder Heads

Cleaning

With valves installed to protect the seats, remove deposits from the combustion chambers and valve heads with a scraper and a wire brush. **Be careful not to damage cylinder head gasket surface.** After valves are removed, clean valve guide bores with a valve guide cleaning tool. Use cleaning solvent to remove dirt, grease and other deposits; clean all bolt holes; ensure valve seats, gasket surfaces and oil return passages are clean. Clean all valve assembly components using a suitable solvent and dry thoroughly.

Inspection

Examine cylinder head for cracks in combustion chambers, intake and exhaust valve ports, and around intake valve seats. Inspect exhaust valve seat inserts for looseness burned or cracked condition. Inspect gasket and sealing surfaces for scratches or mars which may cause leakage after assembly.

Pre-cup insert cracking is acceptable from the throat of the pre-combustion chamber. The cracking becomes unacceptable if the cracks extend beyond the fire ring. Acceptable and unacceptable pre-cup cracks are shown in Fig. 117. Replace unacceptable pre-combustion chambers.

Using a straight edge and a 0.15mm (0.006 inch) feeler gauge, check cylinder head gasket surface for warpage (Fig. 118).

Replace cylinder head if is cracked or warped.

NOTE: Cylinder heads cannot be resurfaced.

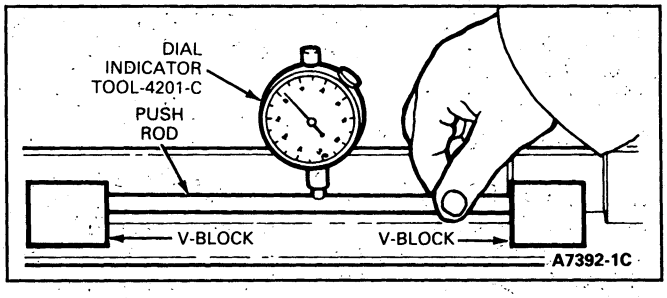


FIG. 116 Checking Push Rod Runout

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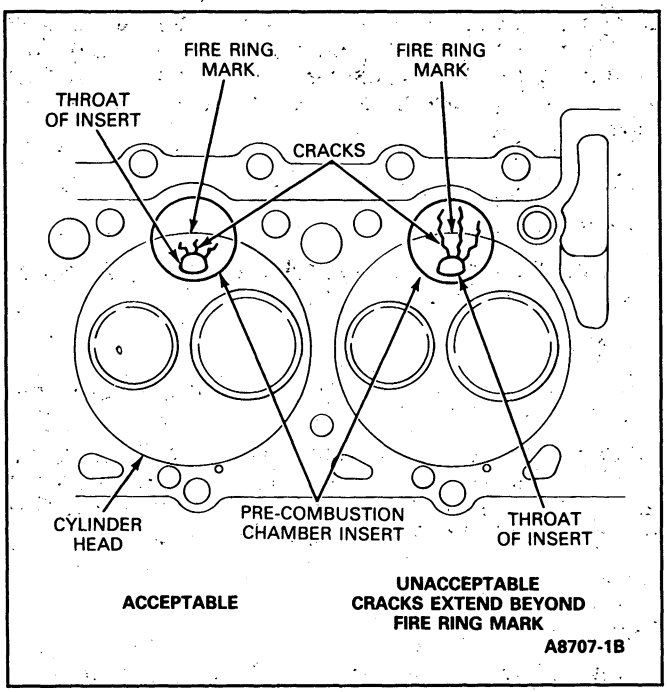


FIG. 117 Pre-Combustion Chamber Cracking

Valve Seat Runout

Check valve seat runout with Valve Seat Runout Gauge D81P-6002-E, or equivalent (Fig. 119). Follow instructions of gauge manufacturer. If runout exceeds service limit, reface valve and valve seat.

Valve Seat Width

Measure valve seat width (Fig. 102). Reface valve seat(s) as outlined if width is not within specifications.

Valves

Critical inspection points and tolerances of valve are illustrated in Fig. 104. Refer to specifications for service limits. Remove all carbon from valve stems and valve heads using a fine wire brush or buffing wheel.

Inspect valve face and edge of valve head for pits, grooves or scores. Inspect stem for a bent condition and end of stem for grooves or scores. Check valve head for signs of burning or erosion, warpage and cracking. Minor pits, grooves, etc., may be removed. Discard severely damaged valves.

Visually inspect valve springs, valve spring retainers, locks and sleeves and discard any damaged parts.

Inspect valve keepers for excessive wear and replace in pairs as required. When installing a new valve, always use new valve keepers.

Valve Face Runout

Check valve face runout. It should not exceed specifications. If runout exceeds service limit, valve should be replaced or refaced as described under Refacing Valves.

Valve Stem Clearance

Check valve stem to valve guide clearance of each valve in its respective valve guide with Valve Stem Clearance TOOL-6505-F (3/8 valves); T65T-6505-H(7/16 valves); Dial Indicator D78P-4201-G, and Dial Indicator Bracket D78P-4201-F, or equivalent, shown in Fig. 120. Use a flat end indicator point.

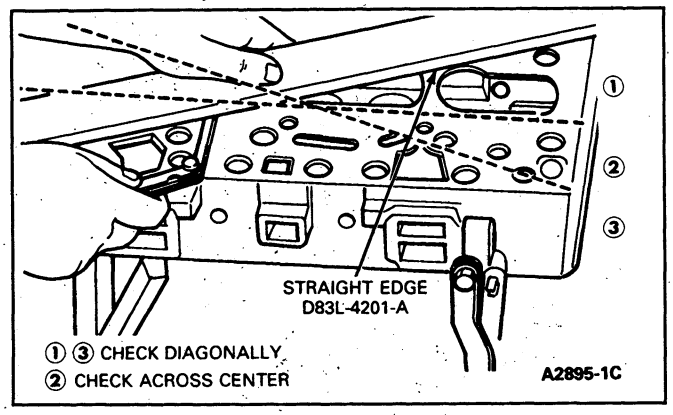


FIG. 118 Checking Cylinder Head Flatness

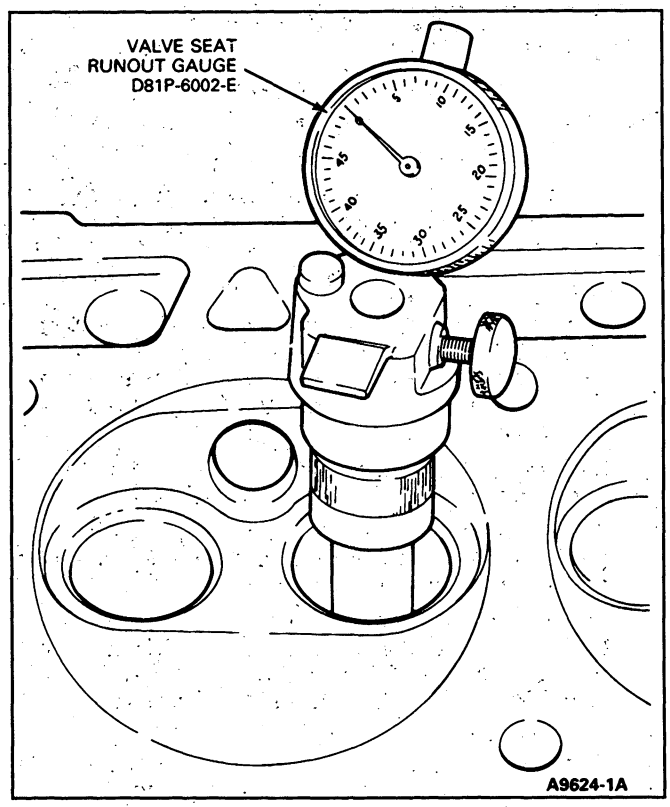


FIG. 119 Checking Valve Seat Runout—Typical

Install tool onto valve stem until fully seated, and tighten knurled set screw firmly. Permit valve to drop away from its seat until tool contacts upper surface of valve guide.

Position dial indicator with its flat tip against center portion of tool's spherical section at approximately 90 degrees to valve stem axis. Move tool back and forth in line with indicator stem. Take a reading on dial indicator without removing tool from valve guide upper surface. Divide reading by two, the division factor for tool. If valve stem to valve guide clearance exceeds specifications, install new valve guide as outlined.

Valve Spring Pressure

Check the valve spring for proper pressure (Fig. 121) at specified spring lengths using Valve/Clutch Spring Tester TOOL-6513-DD or equivalent. Weak valve springs cause poor performance; if pressure of any spring is lower than service limit, replace spring.

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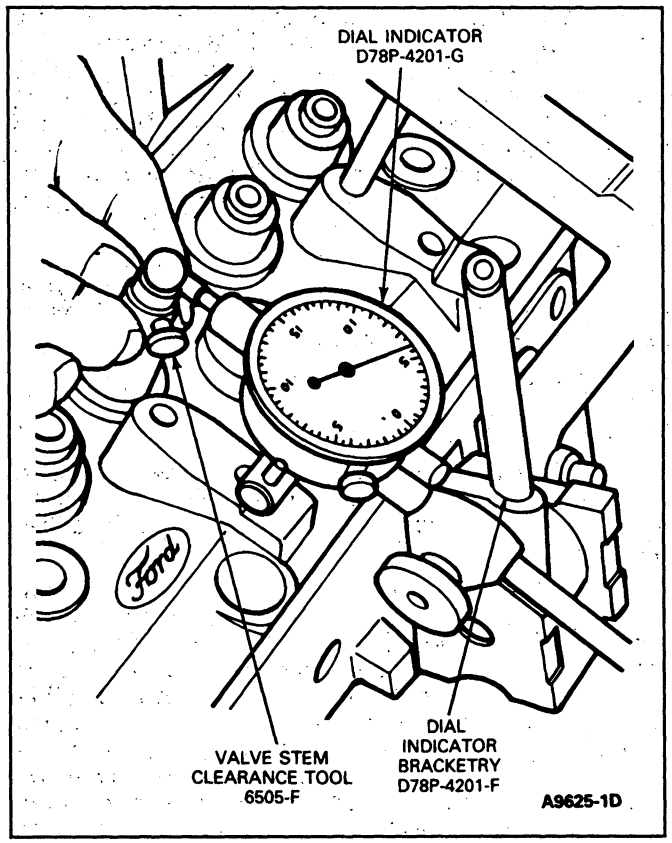


FIG. 120 Check Valve Stem Clearance—Typical

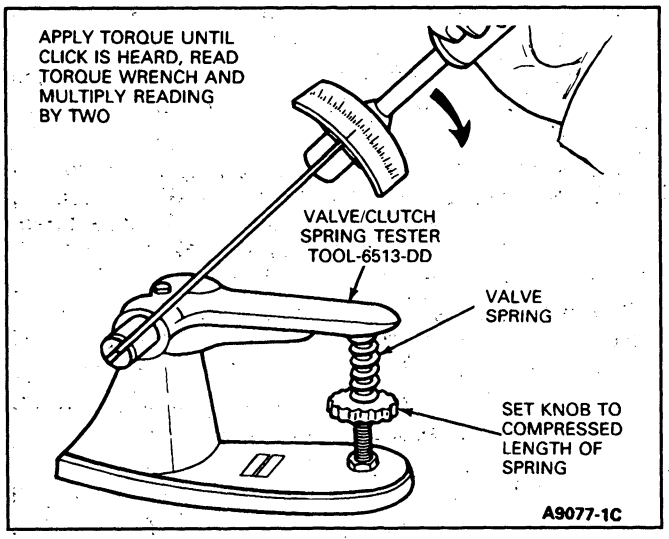


FIG. 121 Checking Valve Spring Pressure

Valve Spring Squareness

Check each spring for squareness using a steel square and a surface plate (Fig. 122). Stand spring and square on end on surface plate. Slide spring up to square. Rotate spring slowly and observe space between top coil of spring and square. If spring is out of square more than 1.984mm (5/64 inch), replace it.

Follow same procedure to check new valve springs before installation.

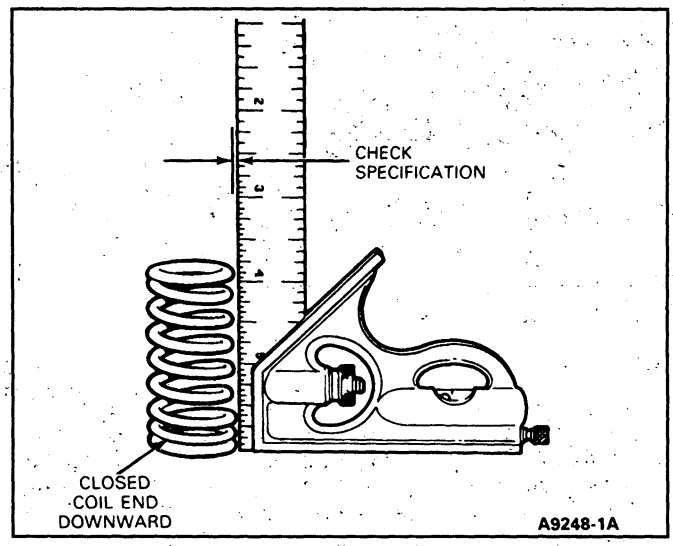


FIG. 122 Checking Valve Spring Squareness

Intake Manifold

Cleaning

Remove all gasket material from machined surfaces of manifold. Clean manifold in a suitable solvent and dry with compressed air.

Inspection

Inspect manifold for cracks, nicked gasket surfaces, or other damage that would make it unfit for further service. Place cylinder head mounting faces of manifold on a smooth, clean surface and check for warpage. Replace manifold if warped or cracked.

Exhaust Manifolds

Cleaning

Remove all gasket material from manifold(s).

Inspection

Inspect manifold(s) for cracks, damaged gasket surfaces, or other wear or damage that would make them unfit for further service. Inspect cylinder head joining flanges of exhaust manifold(s) for evidence or warpage by placing on a flat surface. Minor warpage can be corrected by surface grinding. If warpage is extreme, replace manifold.

Hydraulic Valve Tappets

Valve tappet assemblies should be kept in proper sequence to permit installation into original position. Inspect and test each tappet separately to prevent intermixture of internal parts. **If any part of tappet assembly needs replacing, replace the entire assembly (Fig. 123).**

Disassembly

1. Remove plunger retainer with small screwdriver.
2. Remove push rod seat and metering valve.
3. Remove plunger and plunger spring.

Cleaning

Thoroughly clean all parts in clean solvent and wipe with a clean, lint-free cloth.

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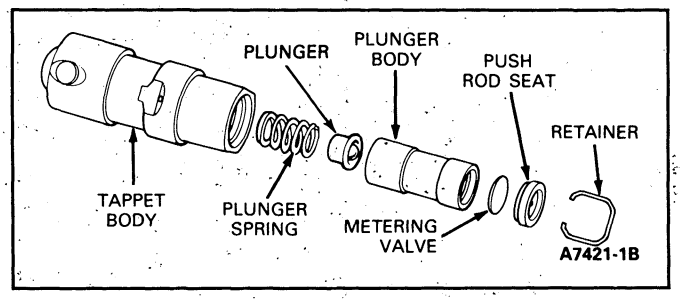


FIG. 123 Tappet Assembly

Inspection

Inspect parts and discard the entire tappet assembly if any part shows pitting, scoring, galling or evidence of non-rotation. Replace entire assembly if the plunger is not free in body. Plunger should drop to bottom of body by its own weight when assembled dry (Fig. 123).

Roller should rotate freely, without excessive play. Check for missing or broken needle bearings. Roller should be free of pits or roughness. If present, inspect camshaft lobes for similar condition. If pits or roughness are evident, replace cam follower and camshaft.

Assembly

1. Coat all parts with specified engine oil.
2. Install plunger spring and plunger into tappet body.
3. Install metering valve and push rod seat into tappet body and install retaining ring.

Check for free operation by pressing down on the push rod cup. Tappets can also be checked with a hydraulic tester to test leak-down rate. Follow instructions provided with test unit.

Camshaft

Clean camshaft in solvent and wipe dry. Inspect camshaft lobes for scoring and signs of abnormal wear. Lobe wear characteristics may result in pitting in general area of lobe toe. This pitting is not harmful to the operation of camshaft; therefore, camshaft should not be replaced unless camshaft lobe lift loss has exceeded specifications.

Check camshaft lobe lift with camshaft installed in engine or on centers. Refer to Camshaft Lobe Lift under Diagnosis and Testing.

Check fuel pump eccentric for excessive wear.

Drive Gears

Cleaning

Clean gears in solvent and dry with compressed air.

Inspection

Inspect gear teeth for scores, nicks, etc. Note condition of tooth contact pattern. If teeth are scored, replace gears.

It is not necessary to replace gears in sets. Replace damaged gears and check backlash, runout, etc, as described in this Section, to determine if any other gear should be replaced.

Crankshaft Vibration Damper

Cleaning

Clean oil seal contact surface on crankshaft damper sleeve with solvent to remove any corrosion, sludge or varnish deposits. Excess deposits not readily removable with solvent may be removed with crocus cloth. Use crocus cloth to remove any sharp edges, burrs or other imperfections which might damage oil seal during installation or cause premature seal wear. **Do not use crocus cloth to the extent that seal surface becomes polished. A finely polished surface may produce poor sealing or cause premature seal wear.**

Inspection

Inspect crankshaft vibration damper sleeve oil seal surface for nicks, sharp edges or burrs that might damage oil seal during installation.

Crankshaft

Cleaning

Handle crankshaft with care to avoid possible fractures or damage to finish surfaces. Clean crankshaft with solvent, and blow out all oil passages with compressed air.

Clean oil seal contact surface at rear of crankshaft with solvent to remove any corrosion, sludge or varnish deposits. Excess deposits not readily removable with solvent may be removed with crocus cloth. Use crocus cloth to remove any sharp edges, burrs or other imperfections which might damage oil seal during installation or cause premature seal wear. **Do not use crocus cloth to the extent that seal surfaces become polished. A finely polished surface may produce poor sealing or cause premature seal wear.**

Inspection

Inspect main and connecting rod journals for cracks, scratches, grooves or scores.

Measure diameter of each journal at least four places to determine out-of-round, taper or undersize condition (Fig. 124).

Bearing failures can cause overheating of crankshaft journals and a reduction of hardness. When this occurs, the crankshaft strength may be unacceptably reduced. Whenever bluing is found on the journal or fillet area, the crankshaft must be replaced.

Crankshafts must not be straightened. Even slight straightening with complete absence of cracks will endanger the high strength built into the shaft.

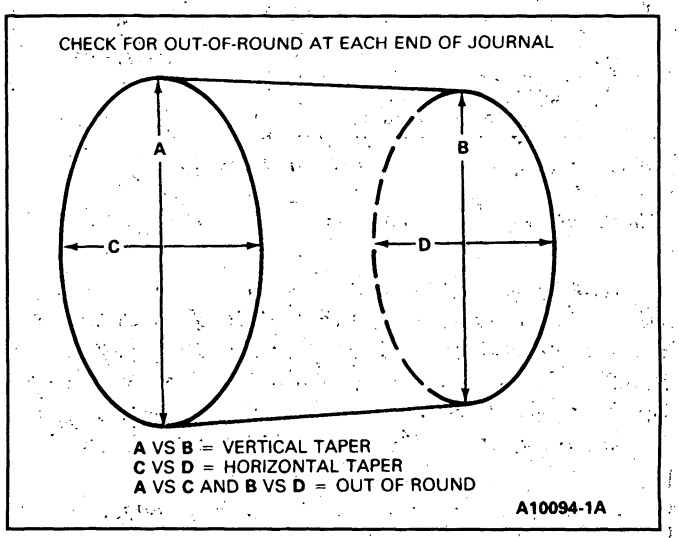


FIG. 124 Crankshaft Journal Measurement

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Flywheel

Automatic Transmission

Inspection

Inspect flywheel for cracks or other damage that would make it unfit for further service. Inspect starter ring gear for worn, chipped or cracked teeth. If teeth are damaged, replace ring gear.

With flywheel installed on crankshaft, check gear face runout of flywheel (refer to Diagnosis and Testing in this Section).

Flywheel

Manual-Shift Transmission

Inspection

Inspect flywheel for cracks, heat checks, or other damage that would make it unfit for further service. Machine friction surface of flywheel if it is scored or worn. If it is necessary to remove more than 1.016mm (0.040 inch) of stock from original thickness, or if flywheel thickness is less than 14mm (0.55 inch) after refacing, replace secondary flywheel. If necessary, refer to Secondary Flywheel Removal and Installation.

CAUTION: Installation of a flywheel less than 14mm (0.55 inch) thick can cause primary flywheel damage.

Inspect ring gear for worn, chipped, or cracked teeth. If teeth are damaged, replace ring gear.

With flywheel installed on crankshaft, check flywheel face runout, following procedure described under Diagnosis and Testing.

Main and Connecting Rod Bearing

CAUTION: In event of bearing failure, the oil cooler must be disassembled and the tube bundle must be replaced.

Cleaning

Clean bearing inserts and caps thoroughly in solvent, and dry with compressed air. **Do not scrape gum or varnish deposits from bearing shells.**

Inspection

Inspect each bearing carefully. Bearings with scored, chipped, or worn surface should be replaced. Typical examples of bearing failure and causes are shown in Fig. 125. Cooper-lead bearing base may be visible through bearing overlay in small localized areas. This may not mean that bearing is excessively worn. **It is not necessary to replace the bearing if bearing clearance is within recommended limits.** Check clearance of bearings that appear to be satisfactory with Plastigage D81L-6002-B, or equivalent. Fit new bearings as outlined.

Connecting Rods

Cleaning

Remove bearings from rod and cap. If bearings are to be reused, mark them to facilitate their installation into original positions. Clean connecting rod in solvent, including rod bore and back of inserts. **Do not use a caustic cleaning solution.**

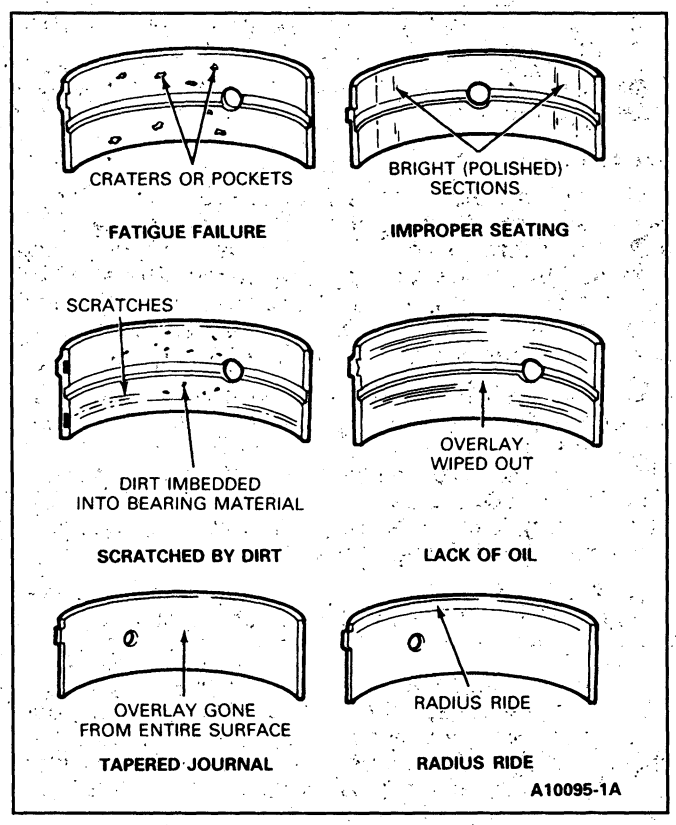


FIG. 125 Typical Bearing Failures

Inspection

Connecting rods and related parts should be carefully inspected and checked for conformance to specifications. Various forms of engine wear caused by these parts can be readily identified.

A shiny surface on edge of piston pin bushing usually indicates that a connecting rod is bent or piston pin hole is not in proper relation to piston skirt and ring grooves.

Abnormal connecting rod bearing wear can be caused by either a bent connecting rod, an improperly machined journal, or a tapered connecting rod bore.

Twisted connecting rods will not create an easily identifiable wear pattern, but badly twisted rods will disturb action of entire piston, rings, and connecting rod assembly, and may be cause of excessive oil consumption.

Inspect connecting rods for signs of fractures. Inspect bearing bores for out-of-round and taper. If bore exceeds maximum limit and/or if rod is fractured, replace rod.

Check ID of connecting rod piston pin bushing. If pin bore is not within specification, replace rod. Replace worn or damaged connecting rod nuts and bolts.

After connecting rods are assembled to piston, check rods for bends or twists on a suitable alignment fixture. Follow instructions of fixture manufacturer. If bend and/or twist exceeds specifications, replace rod.

Pistons, Pins and Rings

Remove deposits from piston surfaces. Clean gum or varnish from piston skirt, piston pins and rings with solvent. **Do not use a caustic cleaning solution or a wire brush to clean pistons.** Clean ring groove with a

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Piston Ring Groove Cleaner D81L-6002-D or equivalent (Fig. 126).

CAUTION: Extreme care must be used when cleaning grooves on aluminum pistons.

Inspection

Carefully inspect pistons for fractures at ring lands, skirts, and pin bosses. Inspect pistons for scuffed, rough, or scored skirts. If lower inner portion of ring grooves have high steps, replace piston. The step will interfere with ring operation and cause excessive ring side clearance. Replace pistons that show signs of excessive wear, wavy ring lands, or fractures.

Check piston-to-cylinder bore clearance by measuring piston and bore diameter. Refer to Cylinder Block Inspection for bore measurement procedure. Measure OD of piston with a micrometer at top of piston skirt and at 90 degrees to pin bore axis, (Fig. 109). Check ring side clearance following procedure described under Fitting Piston Rings.

Replace piston pins showing signs of fracture, etching, or wear. Check piston pin fit in piston and rod. Refer to Piston, Pins and Rings.

Replace all rings that are scored, chipped or cracked. Check ring end gap and side clearance. It is good practice to always install new rings when overhauling an engine. Rings should not be transferred from one piston to another, regardless of mileage.

Cylinder Block

Cleaning

After any cylinder bore repair operation, such as honing or deglazing, clean bore(s) with soap and water. **Thoroughly rinse bore(s) with clean water to remove soap, and wipe bore(s) dry with a clean, lint-free cloth. Wipe bore(s) with a clean cloth dipped in engine oil. If these procedures are not followed, rusting of cylinder bore(s) may occur.**

If engine is disassembled, thoroughly clean block in solvent. Remove old gasket material from all machined surfaces. Remove all pipe plugs sealing oil passages. Thoroughly clean all passages. Blow out all passages, bolt holes, etc., with compressed air.

Remove main oil gallery plug and use a 9.5mm (3/8-inch) diameter brush to clean main oil gallery (Fig. 127). Replace oil plug after coating with Perfect Seal Sealing Compound B5A-19554-A or equivalent, non-hardening sealing compound.

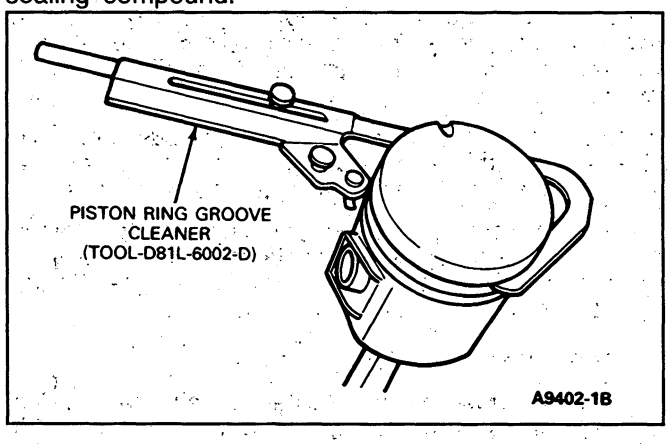


FIG. 126 Cleaning Ring Grooves—Typical

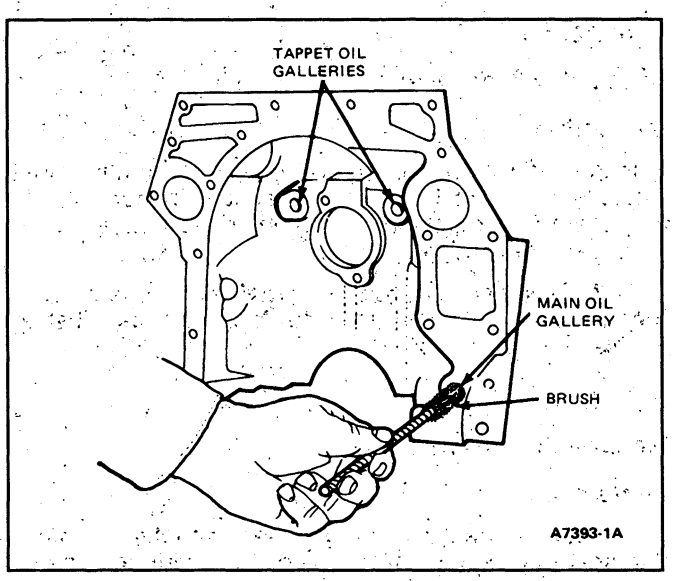


FIG. 127 Cleaning Main and Tappet Oil Galleries with Brush

Remove tappet oil gallery plugs by drilling small hole in plug and prying with a screwdriver or suitable tool. Clean tappet oil galleries with a 8mm (5/16-inch) brush. Replace tappet gallery plugs flush to 1.52mm (.060") below crankcase surface as outlined.

Ensure threads in cylinder head bolt holes are clean. Dirt in threads may cause binding and result in false torque readings. Use tap to true-up threads and to remove any deposits.

Inspection

After block has been thoroughly cleaned, check it for cracks. Minute cracks not visible to the naked eye may be detected by coating suspected area with a mixture of 25 percent kerosene and 75 percent light engine oil. Wipe part dry and immediately apply a coating of zinc oxide dissolved in wood alcohol. Avoid use of methanol substitute rubbing alcohol. If cracks are present, coating will become discolored at cracked area. Replace block if cracked.

Check all machined gasket surfaces for burrs, nicks, scratches and scores. Remove minor imperfections with an oil stone. Check cylinder block for flatness of cylinder head gasket surface following procedure and specifications recommended for cylinder head.

NOTE: If flatness is out of specification, do not resurface top deck of crankcase. Replace cylinder block.

Replace all expansion-type plugs showing evidence of leakage.

Inspect cylinder walls for scoring, roughness, or other signs of wear. Check cylinder bore for out-of-round and taper. Measure bore with an accurate bore gauge following instructions of manufacturer. Measure diameter of each cylinder bore at top, middle and bottom with gauge placed at right angles and parallel to centerline of engine. Use only measurements obtained at 90 degrees to engine centerline when calculating piston-to-cylinder bore clearance.

Refinish cylinders that are deeply scored and/or when out-of-round and/or taper exceed specifications.

If cylinder walls have minor surface damage, but out-of-round and taper are within limits, it may be possible

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to remove such damage by honing cylinder walls and installing new service piston rings, providing piston clearance is within specified limits.

To remove cylinder wall glaze or to refinish a cylinder bore, follow deglazing and honing procedures described under Cylinder Block-Refinishing Cylinder Walls.

Oil Pan

Cleaning

Scrape any dirt or metal particles from inside of pan. Scrape or wire brush all old gasket material from gasket surface. Wash pan in a degreasing solvent and dry it thoroughly. Ensure all foreign particles are removed from below baffle plate.

Inspection

Check pan for cracks, holes and damaged drain plug threads. Check gasket surface for damage caused by over-tightened bolts. Straighten surface as required to restore original flatness.

Replace pan if repairs cannot be made.

Oil Pump

Check oil pump drive gear backlash as outlined. If backlash is out of specification, replace pump. Oil pump is serviced as a complete assembly only.

Oil Cooler

If oil is found in the cooling system, or coolant found in the oil, the oil cooler should be checked for leakage as outlined.

If oil cooler O-rings are leaking, remove oil cooler as outlined. Disassemble and repair as follows.

Disassembly

1. Gently rap front and oil filter headers to loosen O-rings. Twist oil cooler apart (Fig. 128).
2. Thoroughly clean oil cooler, front header, and filter header in suitable solvent. The oil cooler should be thoroughly flushed and drained to remove all residue within it.
3. Use new O-rings when assembling oil cooler. Lubricate all O-ring mating surfaces and O-rings prior to assembly with clean engine oil.

Assembly

1. Install one rust colored O-ring into each header.

   NOTE: The inner O-ring must be installed in the header (not on the bundle) to avoid cutting the inner O-ring during assembly.
2. Place large O-ring over oil cooler shell.
3. Press assembly together ensuring locating clips align in slots.
4. Test oil cooler assembly, as outlined before installing on engine.

Mechanical Fuel Supply Pump

Inspect fuel supply pump for cracks or damage. Inspect mounting flange for distortion. Inspect rocker arm spring, pin and rocker arm for wear, cracks or damage. **If any fuel supply pump components are damaged, replace fuel supply pump.**

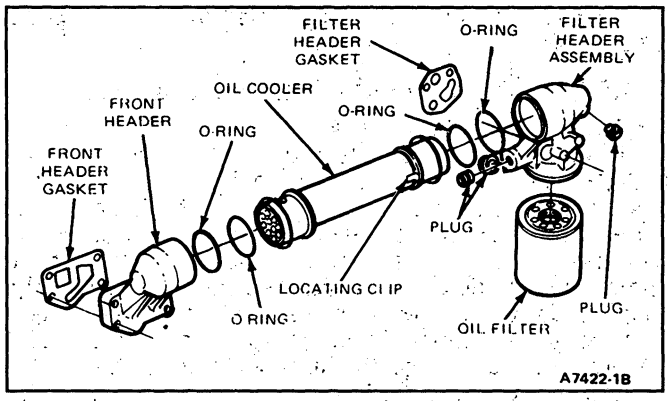


FIG. 128 Oil Cooler

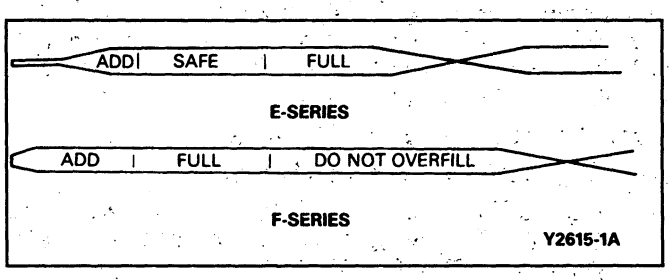


FIG. 129 6.9L Diesel Oil Level Indicators

Thermostat

To check operation, place thermostat in a pan of water, heat water, and using an accurate thermometer, observe water temperature when thermostat starts to open. Thermostat should start to open at approximately 100-107°C (180-192°F) and be fully open at approximately 111-118°C (200-212°F). The thermostat is not adjustable. If it does not operate within above limits, replace it.

If problem being investigated is insufficient heat, thermostat should be checked for leakage. This may be done by holding thermostat up to a lighted background. Light leakage around thermostat valve (thermostat at room temperature) is unacceptable, and thermostat should be replaced.

MAINTENANCE

Engine Oil Level

Check crankcase oil level each time you stop for fuel. Keep the oil level between the **FULL** and **ADD** marks on the dipstick (Fig. 129). The distance between the **ADD** and **FULL** marks on the diesel engine represents two quarts. **DO NOT OVERFILL.**

Engine Fuel Filter

Refer to Owner's and Operator's Guide or Section 10-02, Maintenance in this manual.

Engine Idle Speed

Refer to the Engine/Emissions Diagnosis* Manual for procedures and specifications.

Accelerator Linkage

Check accelerator linkage for sticking or binding. Ensure that throttle lever returns to the idle stop on the injection pump. Service or adjust, as necessary.

*Can be purchased as a separate item.

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Lubricate friction points as specified in Section 10-02, Maintenance, in this manual.

Fuel Filter/Fuel Heater/Water Separator

The 7.3L diesel engine is equipped with a fuel filter/fuel heater/water separator assembly (Fig. 130). A WATER IN FUEL indicator lamp is provided on the instrument panel to alert the operator. The lamp should glow when the ignition switch is in the ON position to indicate proper lamp and water sensor function. If the lamp glows continuously while the engine is running, the water must be drained from the fuel filter/fuel heater/water separator manual drain valve as soon as practical to prevent damage to the fuel injection system.

Drain water from the fuel filter/fuel heater/water separator manual drain valve whenever the warning lamp comes on or every 8,046 km (5,000 miles). The WATER IN FUEL lamp will glow when approximately 103 ml (3.5 fluid ounces) of water accumulates in separator. Refer to Fig. 130.

Drain Procedure—(E and F-Series)

1. Stop vehicle and shut off engine.

   NOTE: To avoid engine stall-out caused by air entering the fuel system, do not drain fuel/water separator while engine is running.

2. Place an appropriate container under the fuel filter/fuel heater/water separator drain tube to collect drain fluid. The drain tube is attached to the manual drain valve at base of water separator drain bowl.

3. Manually open drain valve by unscrewing. Allow drain valve to remain open approximately 15 seconds or until clear (water-free) diesel fuel flows from drain tube. Close drain valve by threading into water separator drain bowl until liquid no longer drains from drain tube.

   WARNING: ENSURE THAT DRAIN VALVE IS FULLY AND SECURELY CLOSED.

4. Re-start the engine and check WATER IN FUEL lamp. The lamp should not glow. If it continues to glow, have fuel system checked and repaired.

Drain all traces of water from the fuel filter/fuel heater/water separator as outlined at 8,046 km (5,000 mile) intervals as specified in the maintenance schedule. At this service interval, if the warning lamp is not glowing, examine the draining fluid to determine when clear diesel fuel flows from the drain tube. Stop draining procedure as soon as clear diesel fuel appears.

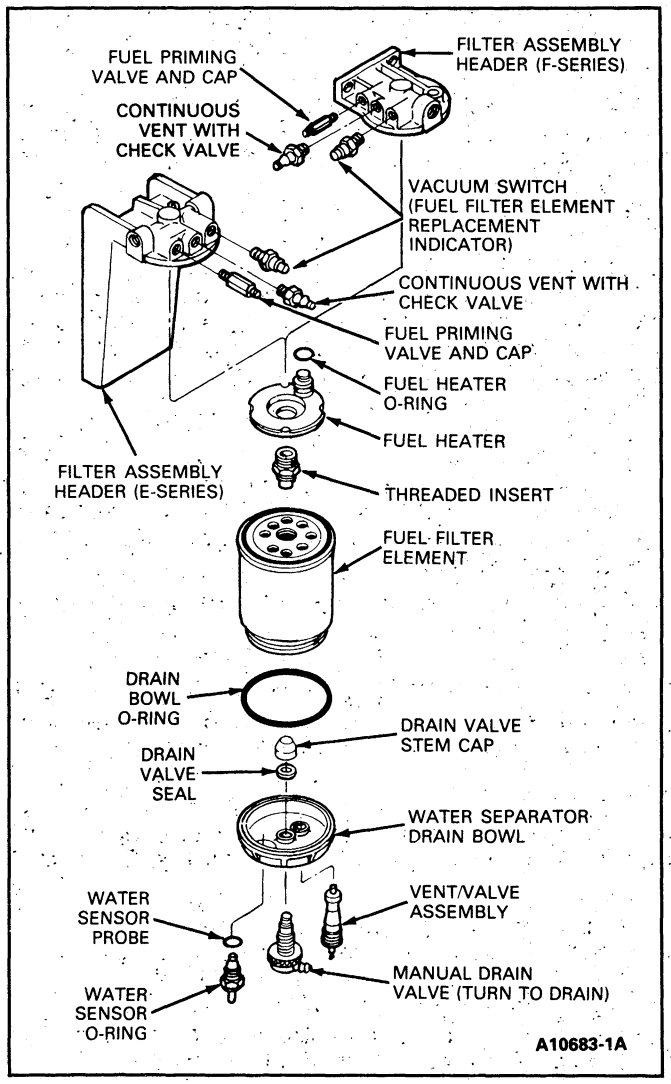


FIG. 130 Fuel Filter/Fuel Heater Water Separator—7.3L Diesel—E and F-Series

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SPECIFICATIONS

GENERAL SPECIFICATIONS

Engine	Bore and Stroke	Firing Order	Oil Pressure Hot @ 3300 RPM kPa (PSI)	Engine Type and Number of Cylinders	Compression Ratio
7.3L Diesel (444 CID)	4.1095 in. x 4.1120 in.	1-2-7-3-4-5-6-8	276-482 kPa (40-70)	O.H.V. V-8	21.5 to 1

Belt Size	Newly Installed ①		Used Over 10 Min.	
	Kg	(lbs)	Kg	(lbs)
All	55-72	120-160	34-54	75-120②

①Tension measured immediately after belt is installed and before it is stretched or seats in pulley grooves (all belts).
②If less than 34 Kg (75 lbs), readjust to 41-54 Kg (90-120 lbs).

CYLINDER HEAD

Engine	Pre-Chamber Insert Protrusion	Valve Guide Bore Diameter		Valve Seat Width①		Valve Seat Runout TIR Maximum	Valve Arrangement Front to Rear	Gasket Surface Flatness ②
		Intake	Exhaust	Intake	Exhaust			
7.3L Diesel V-8	−0.0025 in. +0.0025 in. (−0.064mm/ +0.064mm)	0.3736 in. 0.3746 in.	0.3736 in. 0.3746 in.	0.065"-0.095" (1.651-2.413mm)	0.065"-0.095" (1.651-2.413mm)	0.002 in. (0.05mm)	LT I-E-I-E-I-E-I-E-I RT E-I-E-I-E-I-E-I	0.003" (0.0762mm) in any 6 in. 0.006" (0.1524mm) overall

①Valve seat angle — Intake 30° and Exhaust 37.5°.
②Gasket surface finish — RMS 60-150.

VALVE ROCKER ARM SHAFT, PUSH RODS AND TAPPETS

Engine	Type	Push Rod Runout TIR Maximum	Valve Tappet or Lifter			Collapsed Tappet Gap (Clearance)③
			Standard Diameter	Clearance to Bore①	Hydraulic Lifter Leakdown Rate②	
7.3L Diesel V-8	Hydraulic Roller Follower	0.015 in.	0.9209 in.-0.9217 in. (23.391-23.411mm)	0.0011 in.-0.0034 in. (0.027-0.086mm)	20-110 Sec. For 0.125" Travel	0.185 Max.

①Service limit — .005.
②Time required for plunger to leakdown .125 in. under load of 50 lbs. using leakdown fluid in tappet.
③Measured at valve tip to rocker arm.

VALVE SPRINGS

Engine	Valve Spring Compression Pressure Lbs. @ Specified Height		Valve Spring Free Length (Approximate)		Valve Spring Assembled Height		Valve Spring Out of Square Maximum
	Intake①	Exhaust	Intake	Exhaust	Intake	Exhaust	
7.3L Diesel V-8	80 @ 1.833	80 @ 1.833	2.075 in. ± 0.150 in. (52.705mm ± 3.8mm)	2.075 in. ± 0.150 in. (52.705mm ± 3.8mm)	1.767	1.833	5/64 (0.078)

①Service Limit — 10% loss of pressure.

VALVES

Engine	Valve Stem to Guide Clearance①		Valve Face Angle		Valve Face Runout TIR Maximum
	Intake	Exhaust	Intake	Exhaust	
7.3L Diesel V-8	0.0055 in. (0.140mm)	0.0055 in. (0.140mm)	30°	37.5°	0.0015 in. (0.0381mm)

①Service clearance — .0055.

VALVES (Continued)

Engine	Minimum Value Face Margin-Intake Valves	Minimum Value Face Margin — Exhaust Valves
7.3L Diesel V-8	0.112 inch (2.84mm)	0.053 inch (1.35mm)

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VALVES (Continued)

Engine	Valve Stem Diameter		Valve Head Recession Relative To Deck Surface	
	Intake	Exhaust	Intake	Exhaust
7.3L Diesel	.37165-.37235	.37165-.37235	.042-.054 in.(1.06-1.37mm)	.051-.063 in. (1.29-1.60mm)

CAMSHAFT

Engine	Camshaft End Play		Camshaft Journal to Bearing Clearance
	End Play	Service Limit	
7.3L Diesel	.002-.009 inch (.025-.228mm)	—	0.0381-0.0889mm (0.0015-0.0035 in.)

CAMSHAFT DRIVE

Engine	Camshaft Bearing Inside Diameter②					Camshaft Front Bearing Location①	Gear Backlash
	No. 1	No. 2	No. 3	No. 4	No. 5		
7.3L Diesel V-8	2.1015-2.1025 inch (53.37-53.40mm)	2.1015-2.1025 inch (53.37-53.40mm)	2.1015-2.1025 inch (53.37-53.40mm)	2.1015-2.1025 inch (53.37-53.40mm)	2.1015-2.1025 inch (53.37-53.40mm)	0.020-0.050 inch)	0.0015-0.013 inch)

①Distance in inches that front edge of the bearing is installed below the front face of the cylinder block.
②All camshaft journals are 2.0990-2.1000.

INJECTION PUMP DRIVE GEAR BACKLASH — 0.0055-0.0010

CYLINDER BLOCK

Engine	Cylinder Bore Diameter①③	Main Bearing Inside Diameter②	Head Gasket Surface Flatness	Head Gasket Surface Finish	Oversize	
7.3L Diesel	4.1095-4.1115 inch (104.38-104.43mm)	3.3152-3.3162 in. (84.21-84.23mm)	0.003 inch in any 6 in. 0.006 inch overall	RMS 63-125	0.010	4.11425 inch (104.502mm)
					0.020	4.12425 inch (104.756mm)
					0.030	4.13425 inch (105.010mm)

①Maximum out-of-round — .002; Maximum taper — 0.002 inch; Cylinder bore surface finish RMS 15-30.
②With bearing caps tightened in place.

CRANKSHAFT AND FLYWHEEL

Engine		Main Bearing Journal Diameter①	Main Bearing Journal Runout TIR Maximum②	Main Bearing Thrust Face Runout TIR Maximum	Main Bearing Journal Taper Maximum Per Inch	Thrust Bearing Journal Length	Main and Rod Bearing Journal Finish RMS Maximum	Main Bearing Thrust Face Finish RMS Maximum
7.3L Diesel		3.1228-3.1236	0.002 inch	0.001 inch	0.0005 inch	1.1325-1.1355 inch	5-20	5-20
Undersize	0.010	3.1128-3.1136 in						
	0.020	3.1028-3.1036 in.						
	0.030	3.0928-3.0936 in.						

①Maximum out-of-round — 0.0002.
②Service limit — 0.005.

CRANKSHAFT FLYWHEEL (Continued)

Engine		Connecting Rod Journal Diameter①	Connecting Rod Journal Taper Per Inch Maximum	Crankshaft End Play ②	Flywheel and Ring Gear Runout
7.3L Diesel		2.4980-2.4990 in.	0.0005 in.	0.0025-0.0085 in.	0.030 in.
Undersize	0.010	2.488-2.489 in			Flywheel and Ring Gear Concentricity
	0.020	2.478-2.479 in.			
	0.030	2.468-2.469 in.			0.020 in.

①Maximum out-of-round — .0003.
②Service limit — .012.
③Note: Bore diameter of cylinders 1-6 — 4.1095 in. to 4.1115 in. Bore diameter of cylinders **7 and 8 only** — 4.1100-4.1120 in.

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CRANKSHAFT BEARINGS

Engine	Connecting Rod Bearing to Crankshaft Clearance Selective Fit			Main Bearing to Crankshaft Clearance Selective Fit		
	Desired	Allowable	Bearing Wall Thickness Std.	Desired	Allowable	Bearing Wall Thickness Std.
7.3L Diesel	0.0011-0.0036 in.	0.0011-0.0036 in.	—	0.0018-0.0036 in.	0.0018-0.0046 in.	—

CONNECTING ROD

Engine	Piston Pin Bushing I.D.	Rod Bearing I.D.① ③	Rod Length Center to Center	Connecting Rod Alignment Maximum Total Difference		Rod to Crankshaft Assembled Side Clearance
				Twist②	Bend②	
7.3L Diesel	1.1105-1.1108 in.	2.5001-2.5016 in.	7.128-7.132 in.	0.002 in.	0.002 in.	0.012-0.024 in.

①Connecting rod bearing bore maximum out-of-round — .005 and maximum bore taper — .0005.
②Pin bushing and crankshaft bore must be parallel and in same vertical plane within specified total difference when measured at the ends of an 8-inch long bar, 4 inches on each side of rod centerline.
③With bearing caps tightened in place.

PISTON

Engine	Skirt Diameter① ② Standard	Piston to Bore Clearance Selective Fit②	Piston Pin Bore Diameter	Piston Height Above Crankcase	Oversize	
7.3L Diesel	4.10375 in. ± 0.00025 in.	See Note Below	1.1104-1.1106	0.010-0.031	0.010 in.	4.11425 in. ④
					0.020	4.12425 in.
					0.003	4.13425 in.

①Measured at 90 degrees to the pin, at 1.25 inch below oil ring groove.
②Service piston is 4.10375 in. ± 0.00025 in.
②Clearance in cylinder **bores 1-6 only:** 0.0055-0.0085 inch.
Clearance in cylinder **bores 7 and 8 only:** 0.0060-0.0085 inch.
④Oversize service piston specifications are all ± 0.0005 inch.

PISTON PIN

Engine	Length	Diameter	Ring End Clearance	To Piston Pin Bore Clearance ①	To Connecting Rod Bushing Clearance
7.3L Diesel	2.692-2.702 in.	1.1099-1.1101 in.	0.001-0.029 in.	0.0003-0.0007 in.	0.0004—0.0009 in.

①Selective fit.

PISTON RINGS

Engine	Standard Ring Diameters	Side Clearance①			Ring Gap			Oversize	
		Compression		Oil	Compression		Oil		
		Top	Bottom		Top	Second			
7.3L Diesel	4.11 in. (104.39mm)	0.002-0.004 in.	0.002-0.004 in.	0.001-0.003 in.	0.013-0.045 in.	0.060-0.085 in.		0.010 in.	4.120 in.
								0.020 in.	4.130 in.
								0.030 in.	4.140 in.

①Service limit — .002 maximum increase in clearance.

OIL PUMP, OIL COOLER AND OIL CAPACITY

Engine	Oil Pump Pressures		Engine Oil Capacity①			Oil Pump Drive Gear Backlash
	700 RPM	3300 RPM	U.S. Qts.	Imperial Qts.	Liters	
7.3L Diesel	69 kPa (10 psi)	276-482 kPa (40-70 psi)	9	9.7	8.5	0.0056-0.010 in.

①Add 1 U.S. quart (or equivalent in Imperial quarts or liters) when replacing filter.

OIL SEALS

Crankcase Oil Seal Journal Finish	10-20 RMS
Front Oil Seal Journal Finish (On Damper)	10-20 RMS

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SPECIAL TORQUE WRENCH INFORMATION

Use of special tool torquing adapters requires use of calculations from the formula below.

WHERE
T = Desire torque from specifications tables
L = Length of torque wrench in inches/MM
E = Length of adapter in inches/MM
Y = Indicated torque wrench setting/reading

$$Y = \frac{T \times L}{L + E}$$

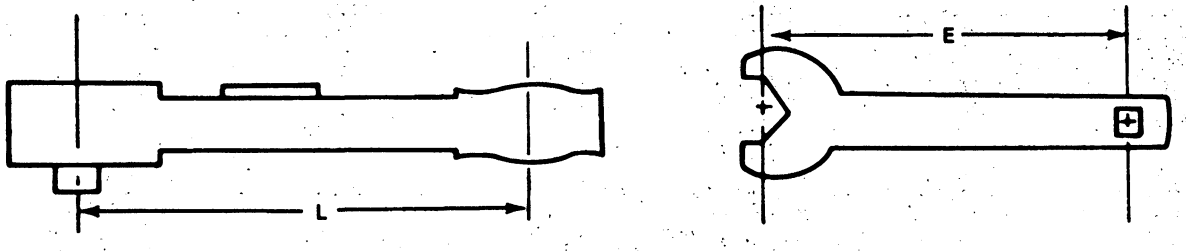
Example: Desired torque from specifications (T) is 100 lb. ft.

Adapter is 8" Long (E)
Torque wrench is 15" Long (L)

$$Y = \frac{100 \times 15}{15 + 8}$$

$$Y = \frac{1500}{23}$$

Y = 65 (Approx.)



Note: Units for L or E may be either metric or inches — but same units must be used for both.

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TORQUE LIMITS — 7.3L V-8 DIESEL ENGINE

NOTE: Unless otherwise specified, use standard torque chart. Torque values are with threads and washer faces coated with engine oil. Torque values are listed without tolerance. Variations to torque will occur due to torque wrench calibration. Variation should be within 10% of nominal values.

STANDARD TORQUE

1/4x20 UNC	5/16-18 UNC	3/8-16 UNC	7/16-14 UNC	1/2x13 UNC
9.5 N•m (7 ft-lb)	19 N•m (14 ft-lb)	32 N•m (24 ft-lb)	51 N•m (38 ft-lb)	81 N•m (60 ft-lb)

PIPE THREADS

1/8x27	1/4x18	3/8x18	1/2x14
7-11 N•m (5-8 ft-lb)	17-24 N•m (12-18 ft-lb)	30-44 N•m (22-33 ft-lb)	34-47 N•m (25-35 ft-lb)

Item	N•m	See Note	Ft-Lb
Air Cleaner Stud Adapter 61 N•m (45 ft-lb.) (See Note ⑨)			
Camshaft Gear Screw	20		15
Connecting Rod Nut		②	
Crankcase Front Cover		①	
Cylinder Head Bolts (New)		③	
Damper to Crankshaft	122		90
CDR Valve		①	
Fan Clutch to Water Pump (LH Thread)	61		163
Fuel Supply Pump		①	
Fuel Filter Adapter to Bracket	33-52		24-39
Fuel Filter Bracket to Cylinder Block	33-52		24-39
Fuel Filter to Adapter	1/2 turn after gasket contacts sealing surface		
Flywheel to Crankshaft	64	⑨	47
Main Bearing Cap Bolts		④	
Manifold — Exhaust (with Prevailing Torque Bolt)	47	⑧	35
Manifold — Intake	33	⑥	24
Oil Filter to Header Adapter	1-1/4 to 2 turns after gasket contacts sealing surface — oiled gasket		
Oil Cooler to Cylinder Block		①	
Oil Cooler Plug	21		15
Oil Pan Drain Plug	37		28
Oil Pan to Cylinder Block		①	
Pulley to Vibration Damper		①	
Secondary Flywheel to Primary Flywheel	64		47
Valve Cover Bolt	8	⑦	6
Valve Lever Post Bolt	27		20
Glow Plug	16		12
Nozzle Assembly	47		35
Nozzle Connector Nut (Injection Pipe)	30		22
Injection Pump Outlet Fitting Nut	30		22
Injection Pump Gear Cover	19	⑨	14
Injection Pump Gear Mounting Bolts	34		25
Water Pump to Front Cover	19	⑤	14
Heater Hose Connector (Water Pump, Cylinder Head)	17-24		12-18
Alternator Bracket to Cylinder Block	33-52		24-39
Alternator Pivot Bolt	38-71		28-53
Alternator Support Bracket to Water Pump	33-52		24-39
Alternator Adjusting Arm to Support	33-52		24-39
Alternator Adjusting Bolt	33-52		24-39
Water Outlet (Thermostat)	27		20

① Use Standard Torque Chart Above.
② Tighten to 51 N•m (38 ft-lb), then to 69 N•m (51 ft-lb).
③ Tighten to 88 N•m (65 ft-lb), then to 122 N•m (90 ft-lb), then 135 N•m (100 ft-lb).
④ Tighten to 101 N•m (75 ft-lb), then to 129 N•m (95 ft-lb).
⑤ RTV Sealer required, refer to Light Truck Engine Shop manual.
⑥ Tighten to 33 N•m (24 ft-lb), then tighten again in sequence.
⑦ Tighten to 8 N•m (6 ft-lb), then tighten again to 8 N•m (6 ft-lb) in sequence.
⑧ Tighten to 47 N•m (35 ft-lb), then tighten again to 47 N•m (35 ft-lb) in sequence. Apply anti-seize compound prior to installation.
⑨ Apply Lock'n Seal® to all threads prior to assembly.

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SPECIAL SERVICE TOOLS

Tool Number	Description	Tool Number	Description
T50T-100-A	Impact Slide Hammer	D83T-6084-A	Exhaust Valve Seat Remover/Replacer
T59L-100-B	Impact Slide Hammer	D83T-6134-B	Cooling Jet Tube Target
D82L-800-B	Hammer	D83T-6136-A	Connecting Rod Installation Guides
T80T-4000-W	Driver Handle	D83T-6250-A	Cam Remover/Replacer Adapter
D78P-4201-F	Dial Indicator Bracketry	T83T-6316-A	Crank/Cam Gear and Damper Remover
D78P-4201-G	Dial Indicator — 1 Inch Travel	T83T-6316-B	Crank/Cam Gear and Damper Replacer
D81L-4201-A	Feeler Gauge	T74P-6375-A	Flywheel Holding Tool
TOOL-4201-C	Dial Indicator w/Bracketry	T83T-6500-A	Tappet Bleed-Down Wrench
T77F-4220-B1	Gear Puller	TOOL-6500-E	Hydraulic Tappet Leakdown Tester
T83T-6000-D6.9	6.9L Essential Service Tool Kit	TOOL-6505-F	Valve Stem Clearance Tool
T70P-6000-	Engine Lifting Brackets	T83T-6513-A	Valve Spring Compressor
D81L-6002-B	Plastigage	TOOL-6513-DD	Valve/Clutch Spring Tester
D81L-6002-C	Piston Ring Compressor	TOOL-6565-AB	Cup Shaped Adapter
D81L-6002-D	Piston Ring Groove Cleaner	T83T-6571-A	Valve Stem Seal Replacer
D81P-6002-E	Valve Seat Runout Gauge	T83T-6700-A	Front Crank Seal Replacer
D83T-6002-A	Glow Plug Socket	T83T-6701-A	Rear Crankshaft Seal Replacer
D83T-6250-A	Camshaft Installation Adapter	T83T-6701-B	Rear Crankshaft Seal Pilot
T65L-6250-A	Camshaft Bearing Set	T86T-9000-C	Injection Pump Mounting Wrench
T68P-6135-A	Piston Pin Remover/Replacer	T83T-9000-C	Injection Pump Rotating Tool
D83L-4201-A	Straight Edge	T83T-9395-A	Fuel System Protection Cap Set
T83T-6312-A	Fan Clutch Pulley Holder	T83T-9396-A	Fuel Line Nut Wrench
T83T-6312-B	Fan Clutch Nut Wrench	T83T-9424-A	Intake Manifold Cover
D83T-9000-E	Throttle Control	T83T-9527-A	Nozzle Seat Cleaner
D83T-6015-A	Expansion Plug Replacer	T71P-19703-C	O-Ring Tool
D83T-6134-A	Piston Cooling Jet Installer	T65-6505-H	Valve Stem Clearance Tool (7/16 Valves)
D83T-6085-A	Valve Guide Tools		

CA7423-2F

ROTUNDA EQUIPMENT

Model Number	Description
014-00036	Universal Load Positioning Sling
014-00300	Injection Nozzle Tester
014-00301	Injection Nozzle Cleaning Kit
014-00306	Engine Stand Mounting Adapter
014-00312	Engine Lifting Bracket
014-00701	Compression Tester
014-00702	Pressure Test Kit
014-00726	Oil Cooler Internal Leakage Tester
112-00001	Oil Leak Detector

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GROUP

IGNITION SYSTEM 23

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VEHICLE APPLICATION

All Light Truck Models.

DESCRIPTION

The Ignition System is TFI-IV with either a universal distributor or a closed bowl distributor (Figs. 1 and 2). The system used depends on engine calibration.

Distributor Assembly—TFI-IV

Universal Distributor

The TFI-IV, EEC-IV engine ignition system features a universal distributor design (Fig. 2) or a closed bowl design (Fig. 3) which is cam gear driven and uses no centrifugal or vacuum advance. The distributor is conventionally-mounted on the engine. The distributor has a die-cast base which incorporates an integrally-mounted TFI-IV ignition module, a "Hall effect" vane switch stator assembly, and provision for fixed octane adjustment. **No distributor calibration is required and initial timing is not a normal adjustment.**

The distributor cap, adapter, and rotor are standard design for all applications including the 5.0L engine which was previously a dual level cap and rotor design.

TFI-IV Ignition System

The universal distributor ignition system uses the Thick Film Integrated (TFI)-IV ignition module (Fig. 4). The module is contained in molded thermo-plastic and is mounted on the distributor base. The TFI-IV module features a "push start" mode. This will allow "push starting" of the manual transmission vehicles should it be necessary.

Vehicles equipped with TFI-IV use an E-Core ignition coil. The ignition coil connector allows a tachometer connection, using an alligator clip, without removing the coil connector.

The spark plugs used are 14mm (1/2 inch) standard reach, tapered seat design.

- The TFI-IV module, used with the universal distributor supplies voltage to the PIP (Profile Ignition Pickup) sensor, which then provides crankshaft position information to the module (Fig. 5).
- The TFI module passes this information to the EEC-IV module, which calculates spark timing and sends a signal (spout) to the TFI ignition module to turn off the coil and produce a spark to fire the spark plugs.
- The TFI ignition module determines dwell and limits primary current to a safe value. If there is an open in

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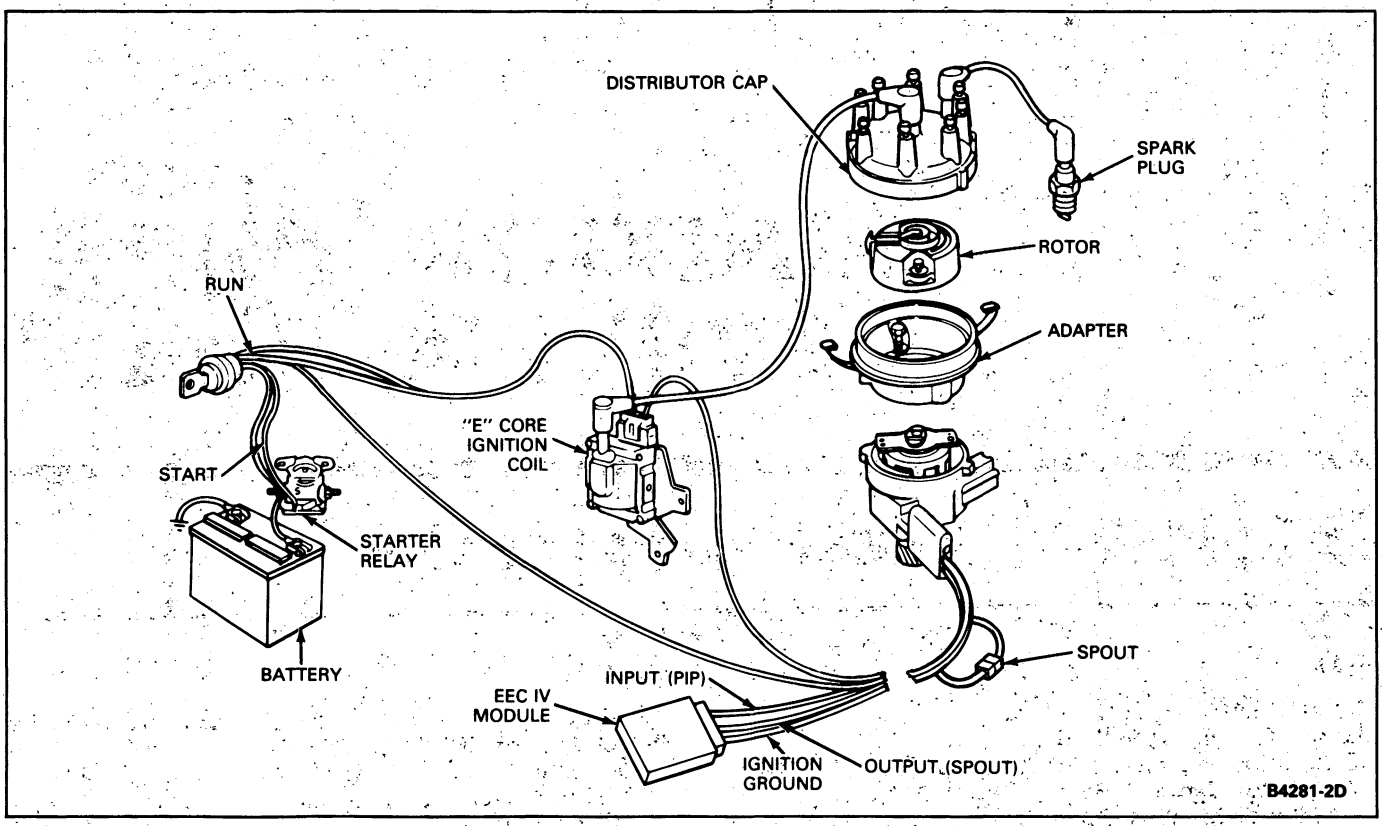


FIG. 1 Thick Film Integrated (TFI) Ignition System with Universal Distributor

the "spout" signal wire, the ignition module will use the PIP sensor signal to provide a spark at base timing.

- The ignition ground is a ground reference signal between the TFI module and the EEC-IV module.

The operation of the universal distributor (Fig. 7) is accomplished by the Hall effect vane switch assembly, which causes the ignition coil to be switched off and on by the EEC-IV and TFI-IV modules. The vane switch is an encapsulated package consisting of a Hall sensor on one side.

A rotary vane cup made of ferrous metal is used to trigger the Hall effect switch. When the window of the vane cup is between the magnet and Hall effect device, a magnetic flux field is completed from the magnet through the Hall effect device and back to the magnet. As the vane passes through the opening, the flux lines are shunted through the vane and back to the magnet.

A voltage is produced while the vane passes through the opening. When the vane clears the opening, the window causes the signal to go to zero voltage. The signal is then used by the EEC-IV system for crankshaft position sensing and the computation of the desired spark advance based on engine demand and calibration. The conditioned spark advance and voltage distribution is accomplished through a conventional rotor (Fig. 8), cap and ignition wires.

ADJUSTMENTS

NOTE: The timing set on TFI ignition systems is not recognized as a normal adjustment. Also, do not change timing by use of different octane rods without first having the proper authorization as federal emission requirements will be affected. Refer to Engine/Emissions Diagnosis* manual and Vehicle Emission Control Information Decal for initial timing and spark plug gap procedure and information.

DIAGNOSIS AND TESTING

Procedures for ignition system diagnosis and testing are shown in the Engine/Emissions Diagnosis* manual.

REMOVAL AND INSTALLATION

Distributor

TFI-IV System

Removal

1. Disconnect the primary wiring connector from distributor.

   NOTE: Prior to removing the distributor cap, mark the position of the No. 1 wire tower on the distributor base for future reference.

2. Using a screwdriver, remove the distributor cap and adapter and position it and the attached wires out of the way.
3. Remove the rotor and place it out of the way to avoid damage.
4. Remove the TFI connector.
5. Remove the distributor hold-down bolt and clamp and remove the distributor. **Do not rotate engine while distributor is removed.**

*Can be purchased as a separate item.

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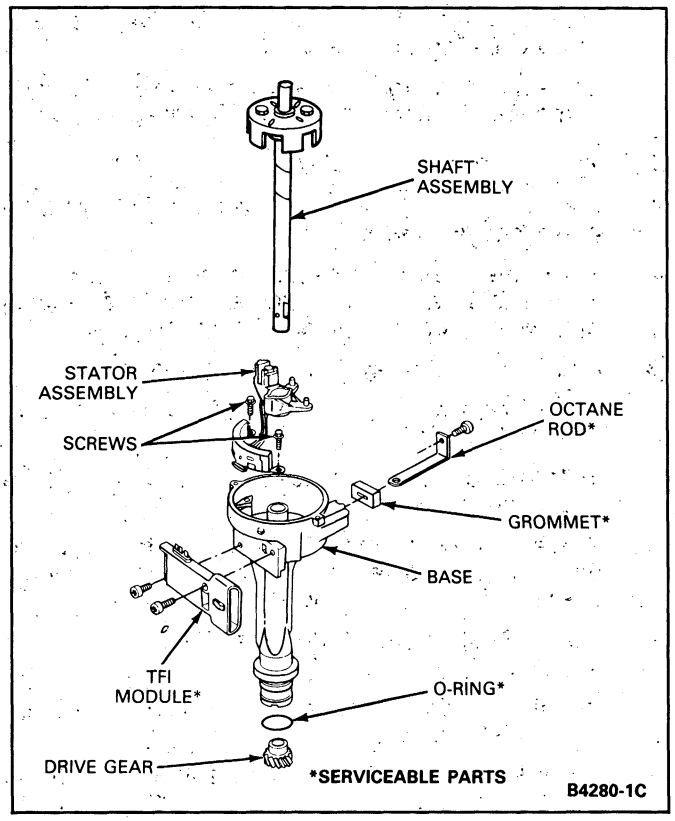


FIG. 2 Universal Distributor Exploded View

Installation

1. Rotate the distributor shaft so that the rotor tip is pointing toward the mark previously made on the distributor base.
2. Continue rotating slightly so that the leading edge of the vane is centered in the vane switch stator assembly.
3. Rotate the distributor in the engine block to align the leading edge of the vane and the vane switch and verify that the rotor is pointing at No. 1 cap terminal.

   NOTE: If the vane and vane switch stator cannot be aligned by rotating the distributor in the engine block, pull the distributor out of the block enough to disengage the distributor and rotate the distributor to engage a different distributor gear tooth. Repeat Steps 3, 4 and 5 as necessary.
4. Install distributor hold-down bolt and clamp. Do not tighten at this time.
5. Connect distributor TFI and primary wiring harnesses.
6. Install the distributor rotor.
7. Install the distributor cap adapter as applicable and tighten the attaching screws 2.8-3.9 N·m (2.1-2.9 ft-lb).
8. Install the distributor cap and wires. Check that the ignition wires are securely attached to the cap and spark plugs.
9. Set initial timing, with a timing light, to specification. Refer to the Vehicle Emission Control Information Decal.

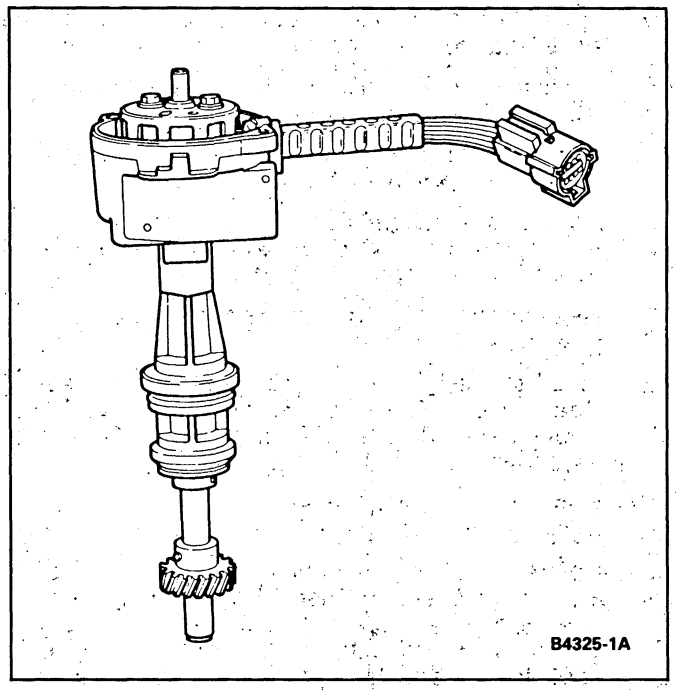


FIG. 3 Closed Bowl Distributor

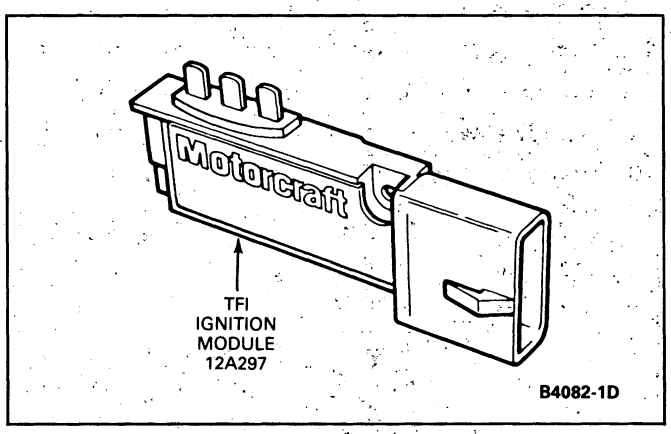


FIG. 4 Ignition Modules

10. Tighten distributor hold-down bolt to 23-34 N·m (17-25 ft-lb).
11. Check and adjust timing, if necessary.

    NOTE: Except for the cap, adapter, rotor, stator, TFI module and O-ring, no other distributor assembly parts are replaceable. There is no calibration required with the universal distributor.

Stator Assembly

(With Electronic Engine Control)

Removal and Disassembly

1. Using a screwdriver, remove the distributor cap. Position the cap and wires aside so as not to interfere with work area. Remove TFI module connector.
2. Remove distributor from block per the distributor removal procedure in this Section.
3. Remove rotor.
4. Remove the two screws holding the TFI module to the base.

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5. Remove the module, wipe the grease from the base and module keeping the surfaces free of dirt.
6. Remove the two screws holding the armature and remove the armature.

   NOTE: Hold the gear to loosen the armature screws, do not hold the armature.
7. To ease the assembling of the stator, mark with a felt tip pen, the armature, gear and collar if present to note orientation.
8. Remove and discard pins in gear and collar if present.
9. Invert the distributor and place in the Axle Bearing Seal Plate T75L-1165-B with Bearing Puller Attachment D84L-1123-A, and press off the gear as shown in Fig. 9.
10. Remove thrust washer from distributor shaft and retain (4.9L only).
11. Before removing shaft from base, check for burrs on end of shaft and especially around drive pin hole. If burrs are present, polish shaft with emery paper and wipe clean before removing shaft from base to prevent damage to bushing in base.
12. After ensuring that there are no burrs, remove shaft assembly by gently pulling up on shaft plate.
13. Remove octane rod retaining screw and retain.
14. Remove octane rod assembly and retain.
15. Remove two stator assembly screws and retain.
16. Remove stator assembly from top of bowl.
17. Inspect base bushing for wear or signs of excess heat concentration, replace complete distributor assembly, if damaged.
18. Inspect base O-ring for cuts or damage and replace O-ring, if necessary.
19. Inspect base for cracks and wear. Replace complete distributor assembly if damage is found.

Installation and Assembly

1. Place the stator assembly over the bushing and press down to seat.
2. Place the stator connector in position. The tab should fit in a notch on the base and fastening eyelets aligned with screw holes.
3. Position wires away from moving parts.
4. Install the two stator screws. Tighten screws to 1.7-4.0 N·m (15-35 in-lb).
5. Install the octane rod, inserting the rod through the base hole (if required).
6. Place the end of the octane rod onto the same post as the original stator, only one post should easily fit into the rod hole.
7. Firmly seat octane rod seal into housing (if required).
8. Install the octane rod screw. Tighten to 1.7-4.0 N·m (15-35 in-lb).
9. Apply lubricant ESF-M2C70-A, 10W30 or 10W40 SFE motor oil or equivalent to the distributor shaft below the armature.

   NOTE: Do not over lubricate.
10. Insert the shaft through the base bushing.
11. Place the collar, if required, over the shaft and line up mark on armature and collar to aid alignment with original drill hole.

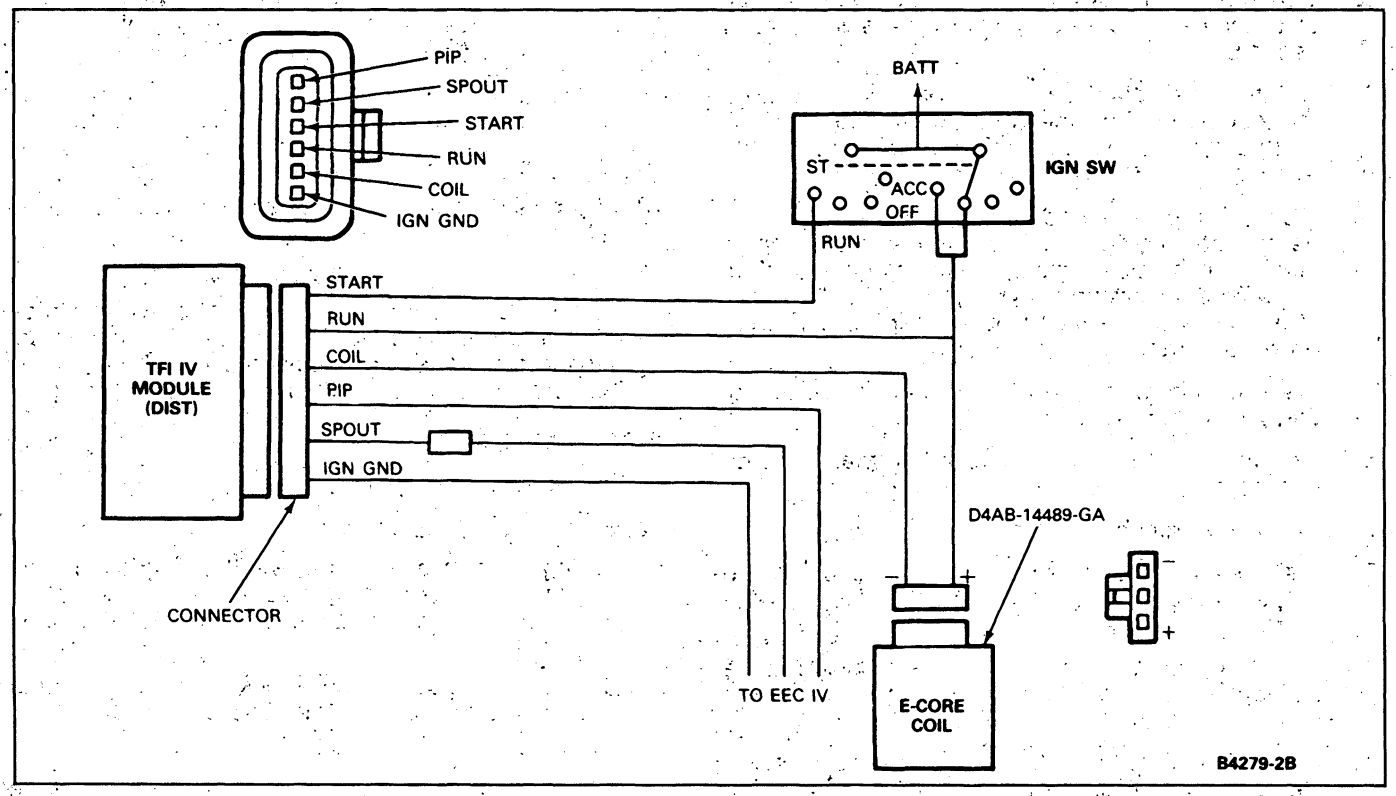


FIG. 5 Typical Thick Film Integrated (TFI) Ignition System with Universal Distirbutor

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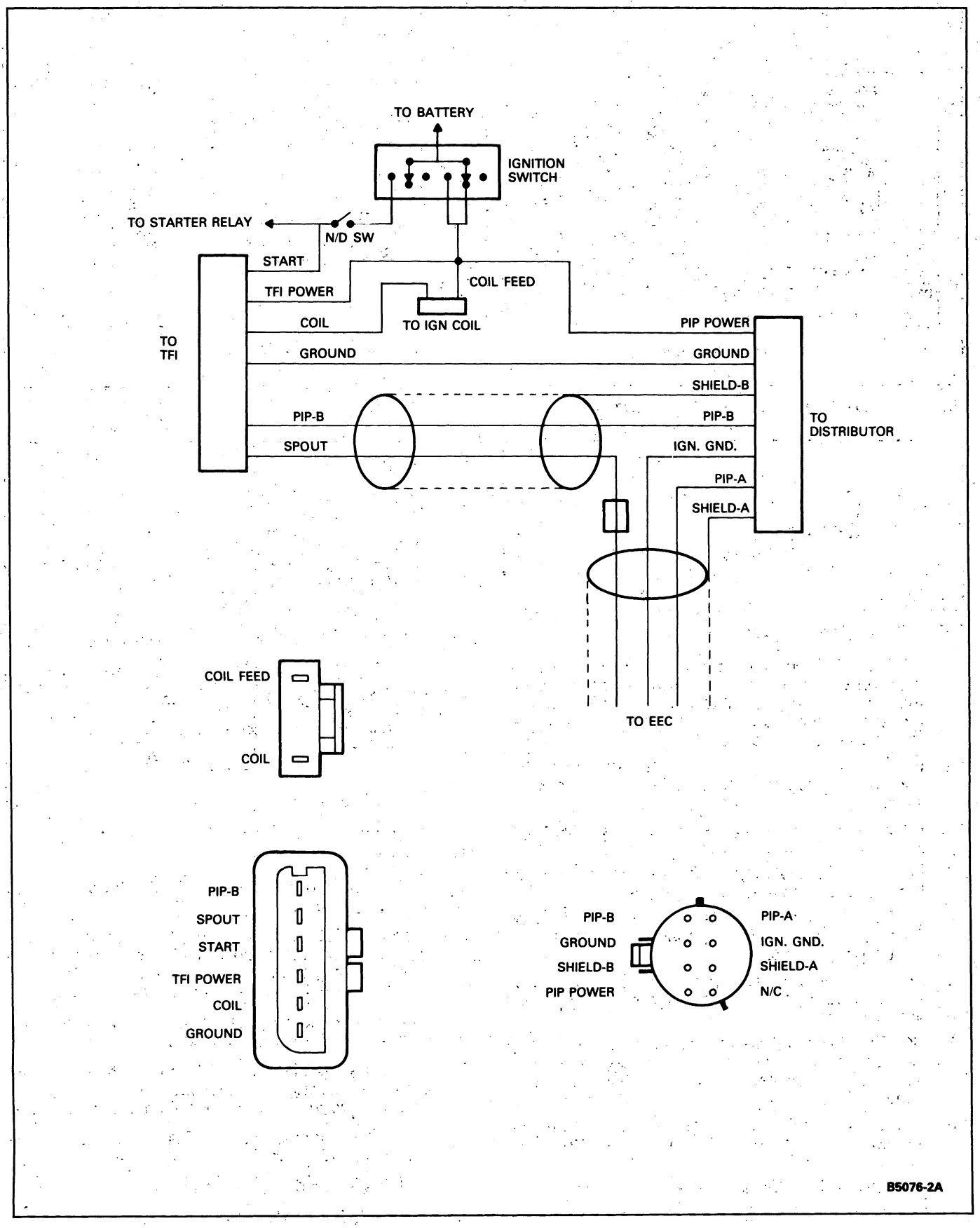


FIG. 6 Typical Thick Film Integrated (TFI) Ignition System with Closed Bowl Distributor

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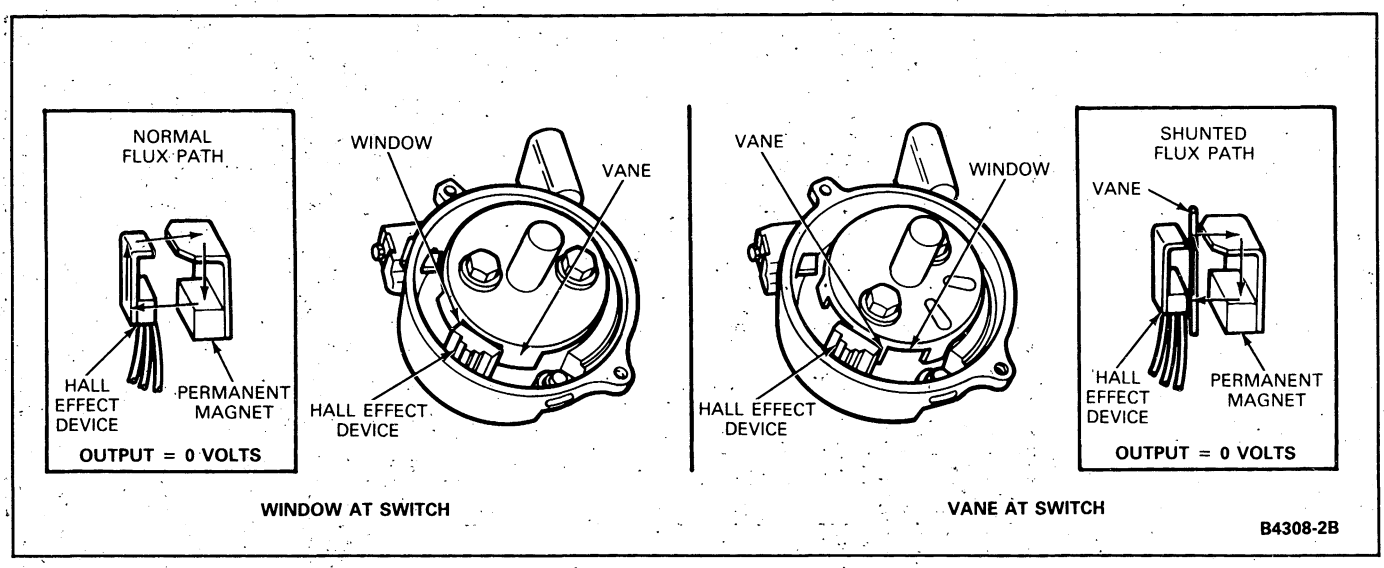


FIG. 7 Universal Distributor Ignition Switching

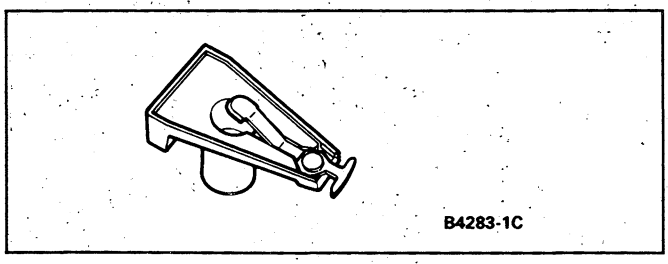


FIG. 8 Blade Rotor—Typical

NOTE: Drill holes through shaft and collar should align on both sides of shaft. If holes do not align, the collar may be 180 degrees out of alignment on the shaft. Rotate the collar on the shaft one half rotation, and then check.

12. Insert new roll pin through collar and shaft. Pin should be flush with both sides of collar when seated.
13. Place a 1/2-inch deep well socket over the shaft, invert and place on arbor plate (Fig. 10).
14. Place the distributor gear on the shaft and line up the mark on the armature and gear.

    NOTE: The hole in the shaft and gear must be lined up as accurately as possible to ensure ease of roll pin insertion.
15. Place a 5/8-inch deep well socket over the shaft and gear, and press gear to align with original drill hole (Fig. 11).

    NOTE: If the gear holes do not align, the gear must be removed and repressed on. A drift punch will not align the holes, as in the collar, the holes should align.
16. Insert a new roll pin through gear and shaft. Pin should have proper extrusion. Refer to chart following Step 7.
17. Replace and tighten armature 2.8-4.0 N·m (25-35 in-lb).
18. Check distributor for free movement over full rotation of shaft.

    NOTE: If the armature hits the stator, replace the entire distributor assembly.

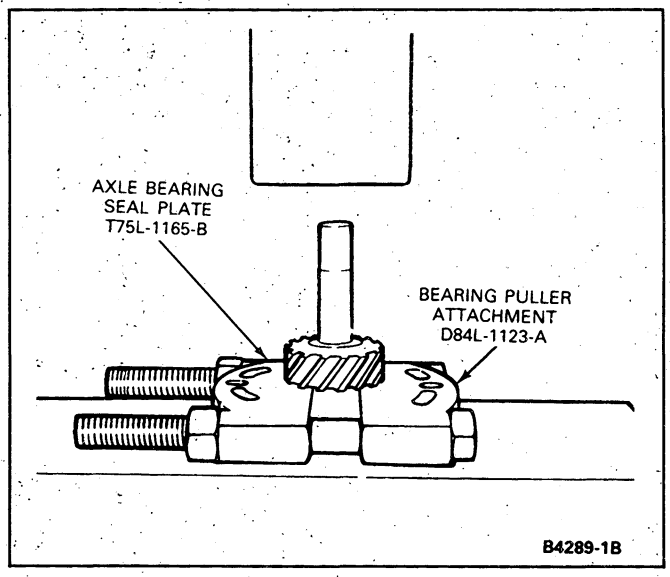


FIG. 9 Stator Gear Removal

19. Wipe back of module and distributor module mounting face free of all dirt.
20. Apply Silicone Dielectric Compound D7AZ-19A331-A or Motorcraft WA-10 or equivalent to the back of the module. Spread evenly, thin, even coverage to the entire back of the module.
21. Turn the distributor base upside down so that the stator connector is in full view.
22. Insert the module and watch that the three module pins are inserted into the stator connector. Fully seat the module into the module and against base.
23. Install two module screws. Tighten screws to 1.7-4.0 N·m (15-35 in-lb).
24. Install the distributor as outlined.
25. Connect TFI module to wiring harness.
26. Replace distributor cap. Tighten screws to 23-34 N·m (17-25 ft-lb).
27. Re-time engine.

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Engine	Gear Pin	Gear Thrust Washer	Gear Roll Pin Extrusion	Collar	Collar Pin
4.9L	67555-S	X	Flush		
7.5L	67775-S2		Extrude Evenly, Both Sides	X	67555-S
5.0L/5.8L	67555-S		Flush	X	67555-S

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Adapter

Refer to Fig. 1.

Removal

1. Remove the secondary wires.
2. Unclip the distributor cap and lift straight off the distributor.
3. Using a screwdriver, loosen the adapter attaching screws and remove the adapter (eight cylinder applications only).

Installation

1. If previously removed, replace rotor.
2. Install adapter in position and tighten attaching screws to 2.8-3.9 N·m (2.1-2.9 ft-lb).
3. Install the cap, noting the square alignment locator, and fasten the clips.
4. Install secondary wires, noting correct locations on the distributor cap.

Ignition Module—TFI-IV

Removal

1. Using a screwdriver, remove distributor cap and adapter. Position it and the attached wires aside so as not to interfere with the work area.
2. Remove TFI harness connector.
3. Remove distributor from engine using security-type Distributor Hold-Down Wrench T82L-12270-A or equivalent.
4. Place removed distributor on work bench. Remove the two TFI module attachment screws.
5. Pull RH side of module down the distributor mounting flange and then back up to disengage module terminals for connector in distributor base. The module may then be pulled toward flange and away from the distributor.

   CAUTION: Do not attempt to lift module from mounting surface prior to moving entire TFI module toward distributor flange as damage to the pins at the distributor/module connector may result.

Installation

1. Coat the metal base plate of the TFI ignition module with silicone compound, approximately .80mm (1/32 inch) thick. Use Silicone Dielectric Compound D7AZ-19A331-A or equivalent grease.
2. Place TFI module on distributor base mounting flange (Fig. 2).
3. Carefully position TFI module assembly towards distributor bowl and engage securely the three distributor connector pins.
4. Install the two TFI module mounting screws. Tighten screws to 1.7-4.0 N·m (15-35 in-lb) (Fig. 2).

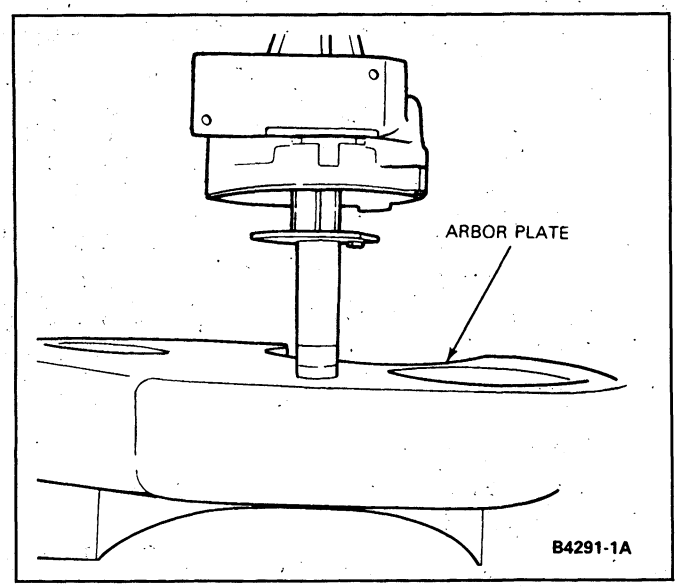


FIG. 10 Distributor with Push-On Rotor

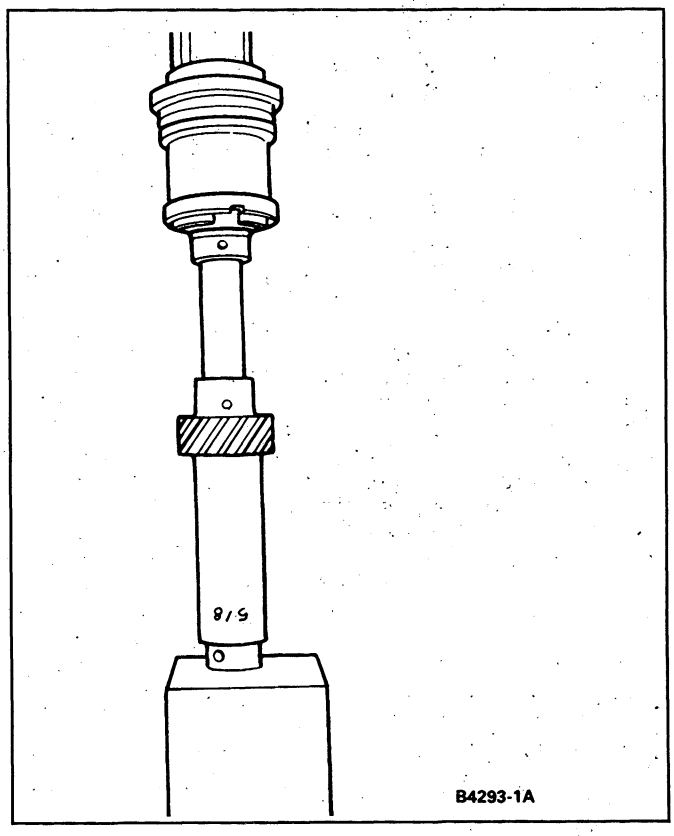


FIG. 11 Drill Hole Alignment

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5. Install distributor on engine.
6. Install distributor cap and adapter. Tighten adapter mounting screws to 2.8-3.9 N·m (2.1-2.9 ft-lb).
7. Install TFI harness connector.
8. Using an induction timing lamp, verify engine timing per specifications on engine decal.
9. If the engine was originally timed with the "positive buy" timing, deface or destroy the "positive buy" timing label.

Octane Rod—TFI-IV

Removal

1. Remove cap, adapter and rotor.
2. Remove the octane rod 4mm (7/32-inch) retaining screw (Fig. 2).
3. Slide the octane rod grommet out to a point where the rod can be disengaged from the stator retaining post and remove the octane rod.

   NOTE: Retain the grommet for use with the new octane rod (Fig. 2).

Installation

1. Install the grommet on the new octane rod.
2. Install the octane rod into the distributor, making sure it engages the stator retaining post.
3. Install the retaining screw. Tighten to 1.8-4.3 N·m (15-35 in-lb).
4. Install the rotor, adapter and cap. Tighten rotor and adapter attaching screws to 2.8-3.9 N·m (2.1-2.9 ft-lb).

Ignition Wires

The ignition wires include the spark plug wires connecting the distributor cap to the spark plugs and the ignition coil wire connecting the distributor cap to the high voltage terminal of the ignition coil.

These wires are designed to reduce radio interference caused by high voltage discharges in the ignition system.

For testing procedures, refer to the Ignition Section of the Engine/Emissions Diagnosis* manual. Do not, under any circumstances, puncture an ignition wire with any type of probing device.

Removal

When removing wires from spark plugs, use Spark Plug Wire Remover T74P-6666-A or equivalent (Fig. 12). Grasp and twist the spark plug wire boot back and forth, then pull the boot off the plug. Do not pull directly on the spark plug wire, or it may separate from its terminal inside the spark plug wire boot.

Installation

Whenever an ignition wire is removed from a spark plug or ignition coil or distributor cap terminal, silicone compound must be applied to the spark plug wire boot before it is reconnected. Using a small, clean tool, lightly coat the entire inner surface of the boot with Silicone Dielectric Compound D7AZ-19A331-A or equivalent.

1. Attach each wire to proper terminal of distributor cap. Be certain wires are fully seated on terminals (Fig. 13).

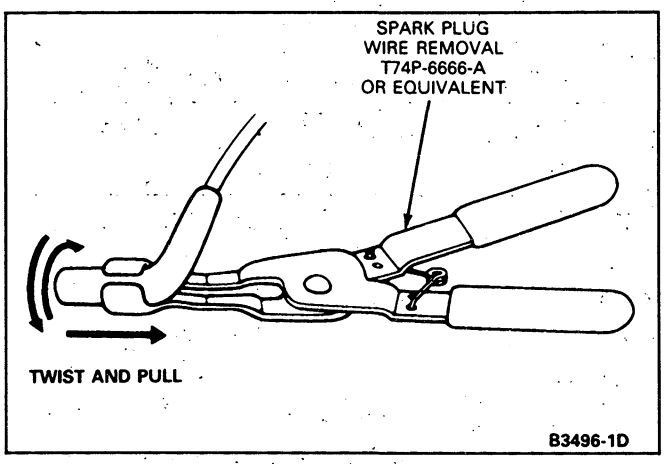


FIG. 12 Removing Wires from Spark Plugs

2. Remove wire separators from old wire set and install them on new set in approximately same position.
3. Connect wires to proper spark plugs. Install ignition coil wire. Be certain all wires are fully seated on terminals.

Distributor Cap and Rotor

Removal and Installation

1. Remove spark plug wires from cap and tag for installation.
2. Remove coil wire from cap.
3. Loosen two captive screws. Remove cap.
4. Remove rotor, if necessary.
5. To install, reverse Steps 1 through 4.

Spark Plug

Removal

1. Remove spark plug wire from spark plug, using Spark Plug Wire Remover T74P-6666-A or equivalent (Fig. 12), with a twisting-pulling motion. Do not pull directly on spark plug wire.
2. Inspect spark plug wires for physical damage. Replace as necessary.
3. Clean area around each spark plug port with compressed air.
4. Remove spark plug.

Installation

1. Set spark plug gap to Specification as shown on Vehicle Emission Control Information Decal.
2. Install spark plug and tighten to Specification.
3. Coat the inside of the spark plug wire boot with silicone compound and install on spark plug.

CLEANING AND INSPECTION

Distributor Assembly

Clean distributor using compressed air. Ensure no metal chips adhere to stator assembly. Inspect distributor to be certain all components are securely attached and stator assembly moves freely. Check that

*Can be purchased as a separate item.

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sleeve and plate assembly rotates freely on distributor shaft.

Distributor Cap and Rotor

Wipe the distributor cap and rotor with a clean cloth dampened with soap and water. Remove any soap film and dry with compressed air.

Examine for cracks, carbon tracking, dirt or missing carbon button in cap. Replace as necessary. Refer to Distributor Cap and Rotor, Removal and Installation.

Spark Plugs

Examine the spark plug for cracked ceramic insulator and condition of firing end. Refer to Fig. 14 for various conditions and actions.

Ignition Wires

Without removing wires from spark plugs, distributor cap or coil, wipe wires with a clean, damp cloth and inspect for visible damage such as cuts, pinches, cracked or torn boots. Replace as necessary.

Ignition Coil

Wipe coil tower with a clean cloth dampened with soap and water. Remove any soap film, then dry with compressed air. Inspect for cracks, carbon tracking and dirt.

Ignition Ballast Resistor

The Ignition Ballast Resistor is actually a specific length of special wire. It is used to limit the primary ignition circuit current in the RUN mode. It is part of the vehicle wiring harness inside the passenger compartment. Under no circumstances should it be cut, spliced or replaced by any other type of non-resistance wire.

Tachometer Connection

The ignition coil connector allows a tachometer connection using an alligator clip without removing the coil connector. Insert the alligator clip into the 'TACH TEST' cavity.

NOTE: Do not allow this clip to accidently ground to a metal surface, it may permanently damage the coil.

Distributor Identification

The distributor assemblies can be identified through the information stamped on a metal tag (Fig. 15) attached to the distributor by a diaphragm assembly attaching screw.

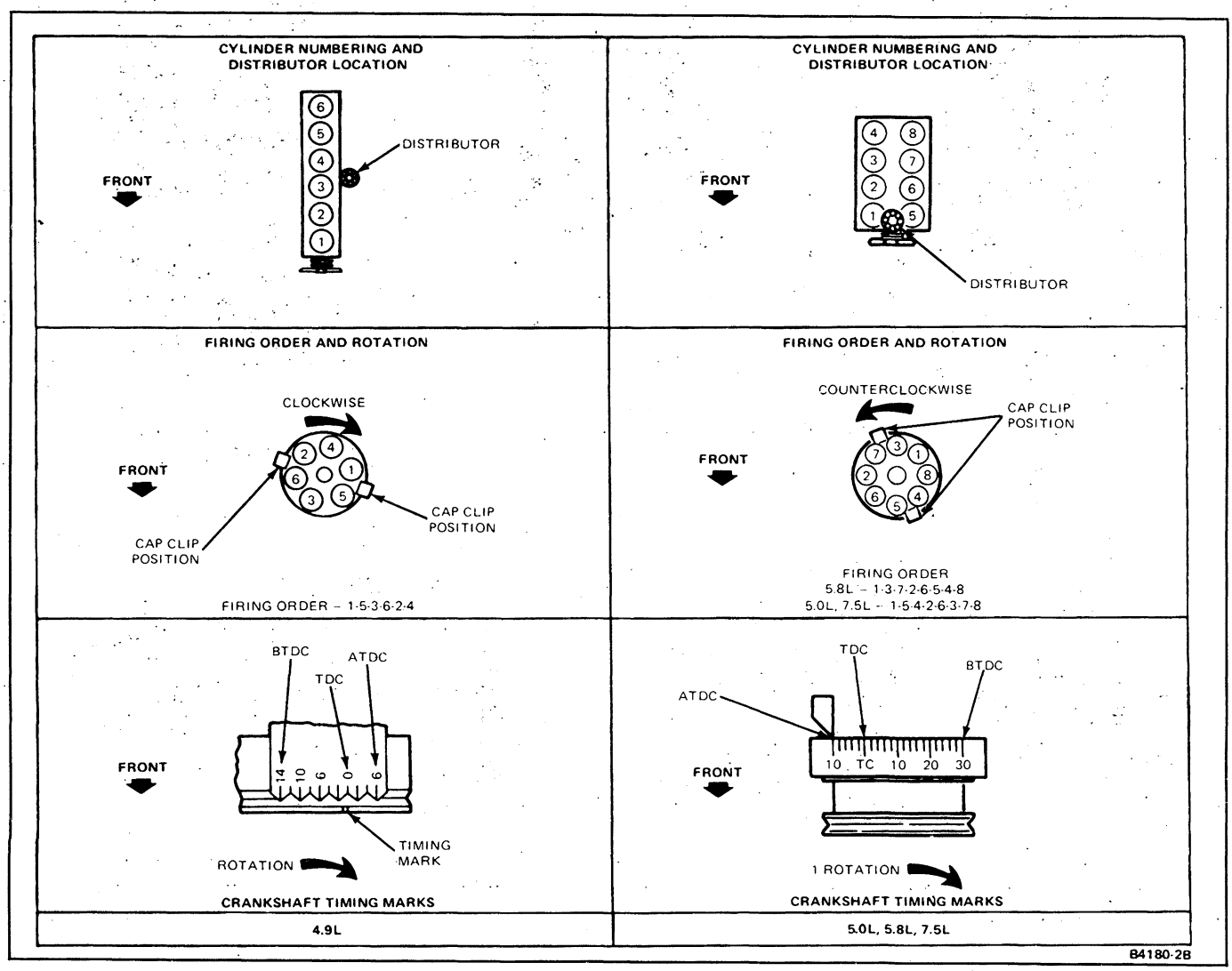


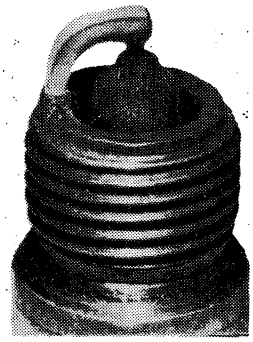
FIG. 13 Engine Firing Order

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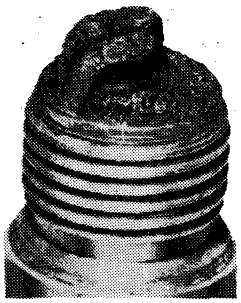
GAP BRIDGED

IDENTIFIED BY DEPOSIT BUILDUP CLOSING GAP BETWEEN ELECTRODES.

CAUSED BY OIL OR CARBON FOULING. REPLACE PLUG, OR, IF DEPOSITS ARE NOT EXCESSIVE, THE PLUG CAN BE CLEANED.



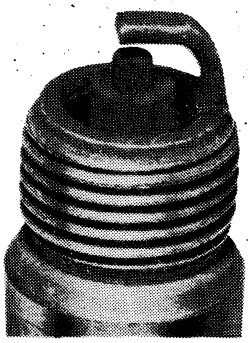
OIL FOULED



IDENTIFIED BY WET BLACK DEPOSITS ON THE INSULATOR SHELL BORE ELECTRODES.

CAUSED BY EXCESSIVE OIL ENTERING COMBUSTION CHAMBER THROUGH WORN RINGS AND PISTONS, EXCESSIVE CLEARANCE BETWEEN VALVE GUIDES AND STEMS, OR WORN OR LOOSE BEARINGS. REPLACE THE PLUG.

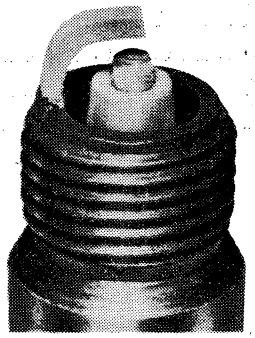
CARBON FOULED



IDENTIFIED BY BLACK, DRY FLUFFY CARBON DEPOSITS ON INSULATOR TIPS, EXPOSED SHELL SURFACES AND ELECTRODES.

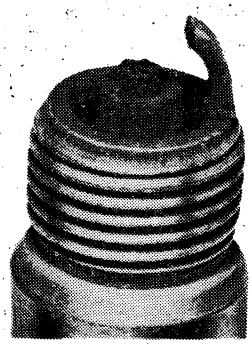
CAUSED BY TOO COLD A PLUG, WEAK IGNITION, DIRTY AIR CLEANER, DEFECTIVE FUEL PUMP, TOO RICH A FUEL MIXTURE, IMPROPERLY OPERATING HEAT RISER OR EXCESSIVE IDLING. CAN BE CLEANED.

NORMAL



IDENTIFIED BY LIGHT TAN OR GRAY DEPOSITS ON THE FIRING TIP.

PRE-IGNITION



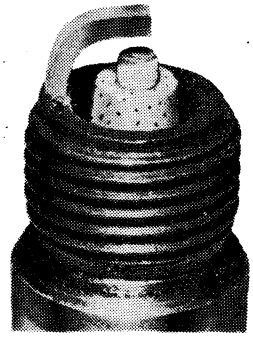
IDENTIFIED BY MELTED ELECTRODES AND POSSIBLY BLISTERED INSULATOR. METALIC DEPOSITS ON INSULATOR INDICATE ENGINE DAMAGE.

CAUSED BY WRONG TYPE OF FUEL, INCORRECT IGNITION TIMING OR ADVANCE, TOO HOT A PLUG, BURNT VALVES OR ENGINE OVERHEATING. REPLACE THE PLUG.

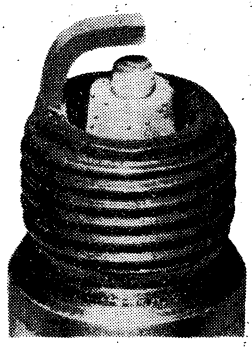
OVERHEATING

IDENTIFIED BY A WHITE OR LIGHT GRAY INSULATOR WITH SMALL BLACK OR GRAY BROWN SPOTS AND WITH BLUISH-BURNT APPEARANCE OF ELECTRODES.

CAUSED BY ENGINE OVERHEATING, WRONG TYPE OF FUEL, LOOSE SPARK PLUGS, TOO HOT A PLUG, LOW FUEL PUMP PRESSURE OR INCORRECT IGNITION TIMING. REPLACE THE PLUG.



FUSED SPOT DEPOSIT



IDENTIFIED BY MELTED OR SPOTTY DEPOSITS RESEMBLING BUBBLES OR BLISTERS.

CAUSED BY SUDDEN ACCELERATION. CAN BE CLEANED IF NOT EXCESSIVE, OTHERWISE REPLACE PLUG.

B4230-2A

FIG. 14 Spark Plug Inspection

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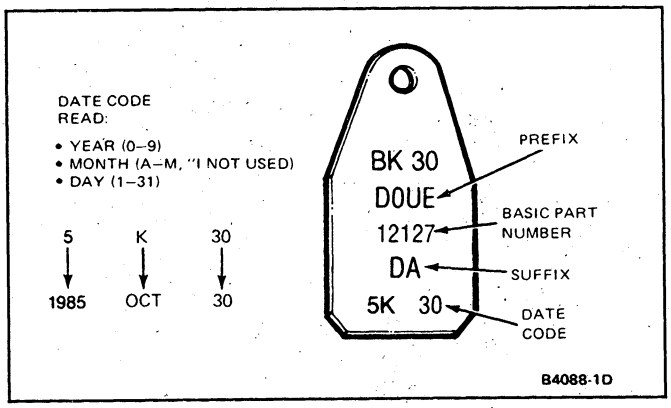


FIG. 15 Distributor Identification

SPECIFICATIONS

TORQUE SPECIFICATIONS

Item		Torque	
		N·m	As Noted
Distributor Hold-down Bolt		23-34	17-25 ft-lb
Distributor Adapter to Distributor Base		2-2.5	18-23 in-lb
TFI Ignition Module Mounting Screw		1.7-4.0	15-35
Spark Plug to Cylinder Head	4.9L	20-27	15-20 ft-lb
	5.0L, 5.8L, 7.5L	9-20	7-15 ft-lb

CB4182-2E

SPECIAL SERVICE TOOLS

Number	Description
D84L-1123-A	Bearing Puller Attachment
T74P-6666-A	Spark Plug Wire Remover
T75L-1165-A	Axle Bearing Seal Plate
T82L-12270-A	Distributor Hold Down Wrench

CB4183-1E

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FUEL SYSTEM—GASOLINE ENGINES

GROUP 24

(9000)

SECTION TITLE	PAGE
FUEL TANKS AND LINES AND FUEL EVAPORATIVE EMISSION CONTROL SYSTEM	24-50-1
AIR CLEANERS—DRY TYPE	24-41-1
ELECTRONIC FUEL INJECTION	24-05-1
ELECTRONIC FUEL INJECTION—4.9L EFI ENGINE	24-10-1
ELECTRONIC FUEL INJECTION—7.5L (460 CID) V-8 ENGINE	24-32-1
FUEL FILTERS—GASOLINE ENGINES	24-51-1
FUEL PUMP—ELECTRIC	24-35-1
GENERAL FUEL SYSTEM SERVICE—GASOLINE ENGINES	24-01-1
THROTTLE LINKAGE	24-60-1

SECTION 24-01 General Fuel System Service—Gasoline Engines

SUBJECT	PAGE
CLEANING AND INSPECTION	
Electric Fuel Pumps	24-01-2
Electronic Fuel Injection—Air Bypass Valve	24-01-2
DESCRIPTION	24-01-1
SPECIFICATIONS	24-01-2
VEHICLE APPLICATION	24-01-1

VEHICLE APPLICATION

All Models.

DESCRIPTION

All engines incorporate a closed-type positive crankcase ventilation system and an exhaust emission system to control engine emissions within Government specifications.

Additional engine performance checks are required to keep the exhaust emissions at the specified minimum pollutant level. Refer to the Pre-Delivery, Maintenance and Lubrication Shop Manual for these performance checks and the recommended intervals.

This Section covers the cleaning and inspection procedures.

For fuel system component removal, disassembly, assembly, installation and major repair procedures, refer to the pertinent Section of this Group.

On all engines requiring unleaded fuel, the "Unleaded Fuel Only" nomenclature must appear:

1. Near the fuel filler opening.
2. On the instrument cluster.

Identification Number

For EFI applications, refer to the EFI Section of this manual.

CLEANING AND INSPECTION

WARNING: DO NOT SMOKE, CARRY LIGHTED TOBACCO OR OPEN FLAME OF ANY TYPE WHEN WORKING ON OR NEAR ANY FUEL-RELATED COMPONENT. HIGHLY FLAMMABLE MIXTURES ARE ALWAYS PRESENT AND MAY BE IGNITED RESULTING IN POSSIBLE HUMAN INJURY.

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Electronic Fuel Injection—Air Bypass Valve

Remove the air bypass valve from the throttle body. Remove the electrical solenoid assembly from the mechanical portion of the air bypass valve by removing the two screws, then sliding the mechanical portion away from the solenoid.

Soak the mechanical portion in Carburetor and Combustion Chamber Cleaner D9AZ-19579-B or equivalent for 2 to 3 minutes maximum.

CAUTION: Do not exceed 3 minutes soak time, and do not use choke cleaner, as an internal O-ring may begin to deteriorate.

With the mechanical portion completely submerged, shake in all directions: up, down, right, and left. Then push in on the rod that mates with the solenoid assembly, and again shake in all directions with the unit submerged and the rod held in as far as possible.

Remove the unit from the cleaning fluid and dry out thoroughly using shop air. Reassemble the air bypass valve to the throttle body, and reset idle to specification, if necessary.

Electric Fuel Pumps

Refer to Section 24-35, Fuel Pump-Electric, for testing procedures.

SPECIFICATIONS

Refer to the Technical Service Bulletin—Special Specifications Issues for the Vehicle Emission Control Information decal (Fig. 1).

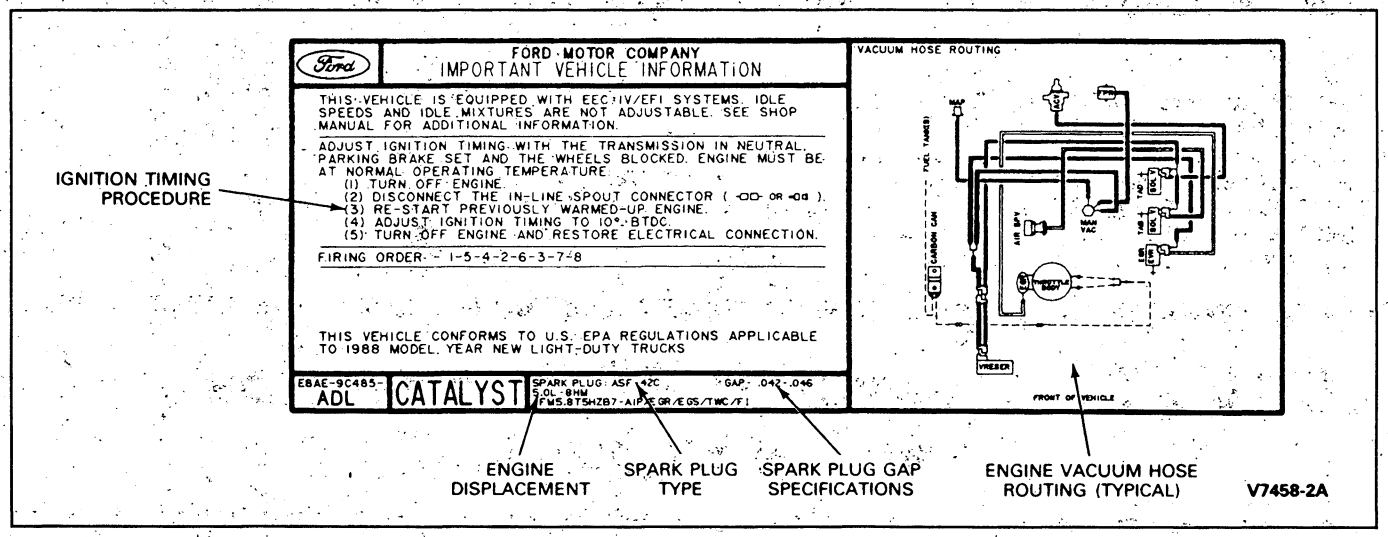


FIG. 1 Typical Engine Exhaust Emission Information Decal

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SECTION 24-05 Electronic Fuel Injection

SUBJECT	PAGE
DESCRIPTION AND OPERATION	
Air Throttle Body Assembly	24-05-5
Components	24-05-2
Air Intake Manifold	24-05-2
Fuel Injectors	24-05-3
Fuel Pressure Regulator	24-05-4
Fuel Supply Manifold Assembly	24-05-5
REMOVAL AND INSTALLATION	
Air Bypass Valve Assembly	24-05-13
Air Intake Throttle Body	24-05-11
Fuel Charging Assembly (Throttle Body, Upper and Lower Manifolds)	24-05-6

SUBJECT	PAGE
REMOVAL AND INSTALLATION (Cont'd.)	
Fuel Injector	24-05-16
Fuel Pressure Regulator	24-05-16
Fuel Supply Manifold Assembly	24-05-14
Lower Intake Manifold	24-05-8
Throttle Position Sensor	24-05-12
SPECIAL SERVICE TOOLS	24-05-17
SPECIFICATIONS	24-05-17
VEHICLE APPLICATION	24-05-1

VEHICLE APPLICATION

5.0L and 5.8L EFI V-8 Engine.

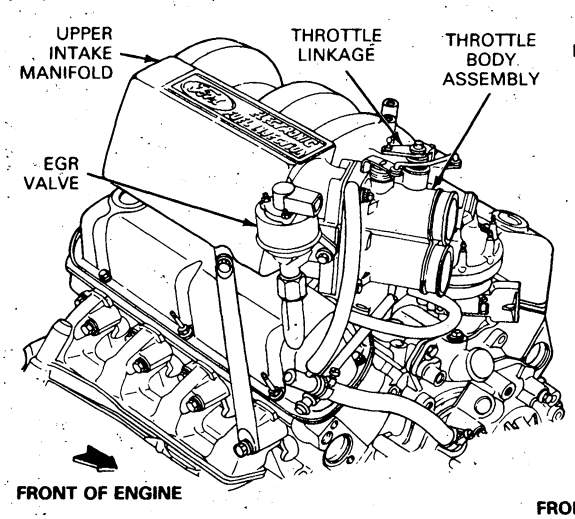
DESCRIPTION AND OPERATION

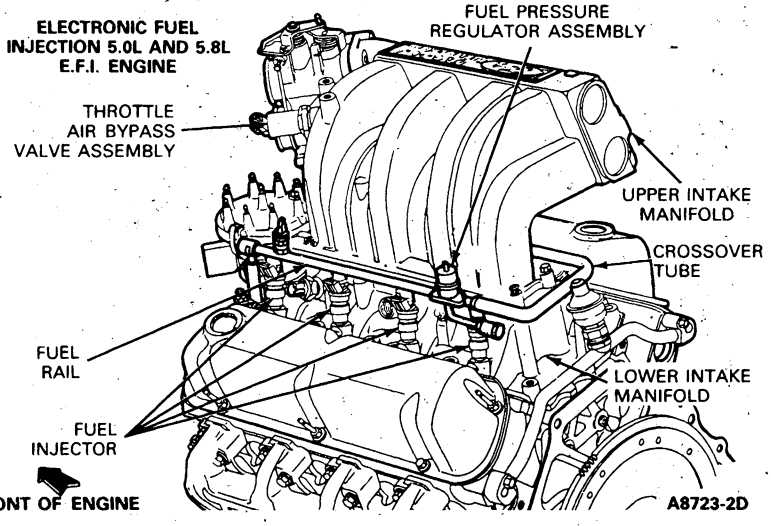
The electronic fuel injection system (EFI) is classified as a multi-point, pulse time, speed density, fuel injection system. Fuel is metered into the intake air stream in accordance with engine demand through eight injectors mounted on a tuned intake manifold.

An on-board electronic engine control (EEC-IV) computer accepts inputs from various engine sensors to compute the fuel flow rate necessary to maintain a prescribed air/fuel ratio at all times. The computer then outputs a command to the fuel injectors to meter the appropriate quantity of fuel.

The EEC-IV engine control system also determines and compensates for the age of the vehicle and its uniqueness. The system will automatically sense and compensate for changes in altitude (i.e. from sea level to mountains) and will also permit push-starting the vehicle should it become necessary (manual transmission only).

The fuel delivery subsystem consists of a low pressure in-tank mounted fuel pump, a fuel reservoir and a high pressure, chassis mounted, electric fuel pump, delivering fuel from the fuel tank through a chassis mounted 20 micron fuel filter to a fuel charging manifold assembly.





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DESCRIPTION AND OPERATION (Continued)

The fuel charging manifold assembly incorporates electrically actuated fuel injectors directly above each of the engine's eight intake ports. The injectors, when energized, spray a metered quantity of fuel into the intake air stream.

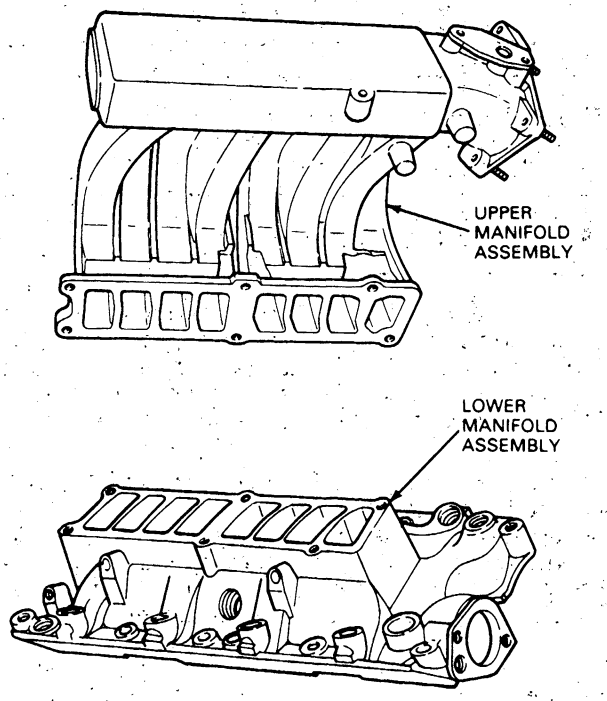
A constant fuel pressure drop is maintained across the injector nozzles by a pressure regulator. The regulator is connected in series with the fuel injectors and is positioned downstream from them. Excess fuel supplied by the pump, but not required by the engine, passes through the regulator and returns to the fuel tank through a fuel return line.

One group of four injectors is energized simultaneously, once every crankshaft revolution followed by the second group of injectors in the next crankshaft revolution. The period of time that the injectors are energized (injector "on time" or pulse width) is controlled by the vehicles' Electronic Engine Control (EEC) computer. The EEC computer receives input from various engine sensors and uses this information to compute the required fuel flow rate necessary to compute the prescribed air/fuel ratio for the given engine operation. The computer determines the needed injector pulse width and outputs a command to the injector to meter the exact quantity of fuel.

Components

Air Intake Manifold

The air intake manifold is a two-piece (upper and lower intake manifold) aluminum casting. Runner lengths are tuned to optimize engine torque and power output. The manifold provides mounting flanges for the air throttle body assembly, fuel supply manifold, accelerator control bracketry and the EGR valve and supply tube. Vacuum taps are provided to support various engine accessories. Pockets for the fuel injectors are machined to prevent both air and fuel leakage. The pockets in which the injectors are mounted are placed to direct the injector fuel spray immediately in front of each engine intake valve.



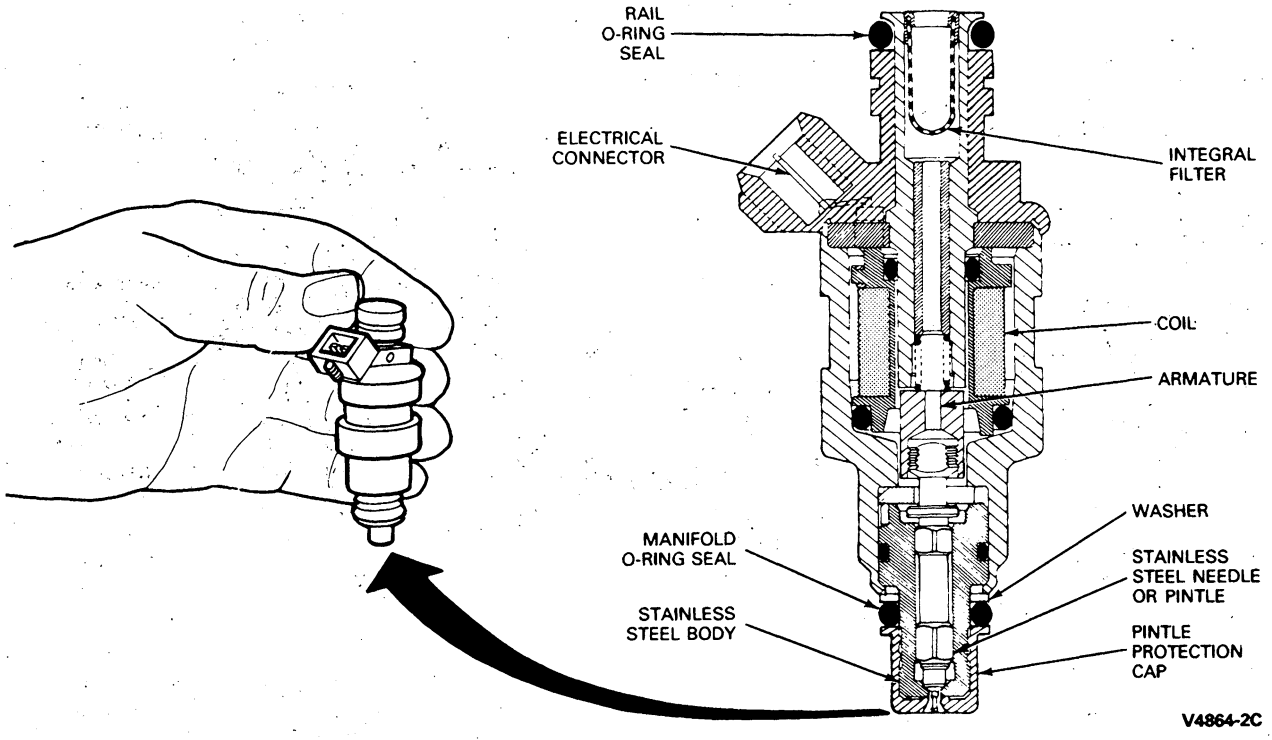
V4764-1A

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DESCRIPTION AND OPERATION (Continued)

Fuel Injectors

The eight fuel injector nozzles are electro-mechanical devices which both meter and atomize fuel delivered to the engine. The injectors are mounted in the lower intake manifold and are positioned so that their tips direct fuel just ahead of the engine intake valves. The injector bodies consist of a solenoid actuated pintle and needle valve assembly. An electrical control signal from the Electronic Engine Control unit activates the injector solenoid, causing the pintle to move inward off the seat, allowing fuel to flow. Since the injector flow orifice is fixed and the fuel pressure drop across the injector tip is constant, fuel flow to the engine is regulated by how long the solenoid is energized. Atomization is obtained by contouring the pintle at the point where the fuel separates.

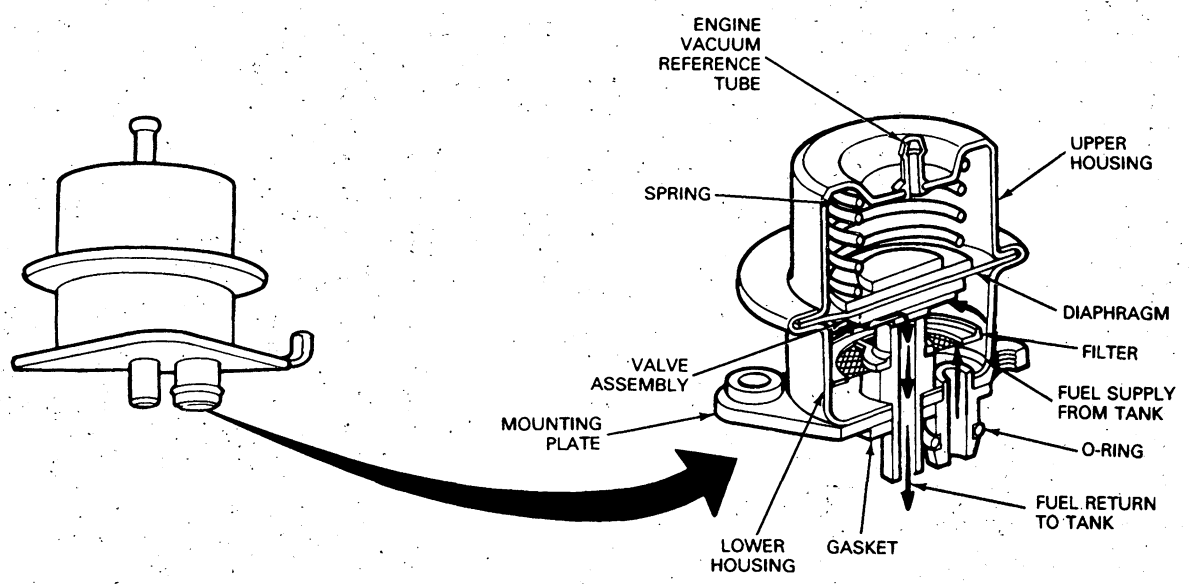


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DESCRIPTION AND OPERATION (Continued)

Fuel Pressure Regulator

The low-profile fuel pressure regulator attaches to the fuel supply manifold assembly downstream of the fuel injectors. It regulates the fuel pressure supplied to the injectors. The regulator is a diaphragm operated relief valve in which one side of the diaphragm senses fuel pressure and the other side is subjected to intake manifold vacuum. The nominal fuel pressure is established by a spring preload applied to the diaphragm. Balancing one side of the diaphragm with manifold pressure maintains a constant fuel pressure drop across the injectors. Fuel in excess of that used by the engine, is bypassed through the regulator and returns to the fuel tank.

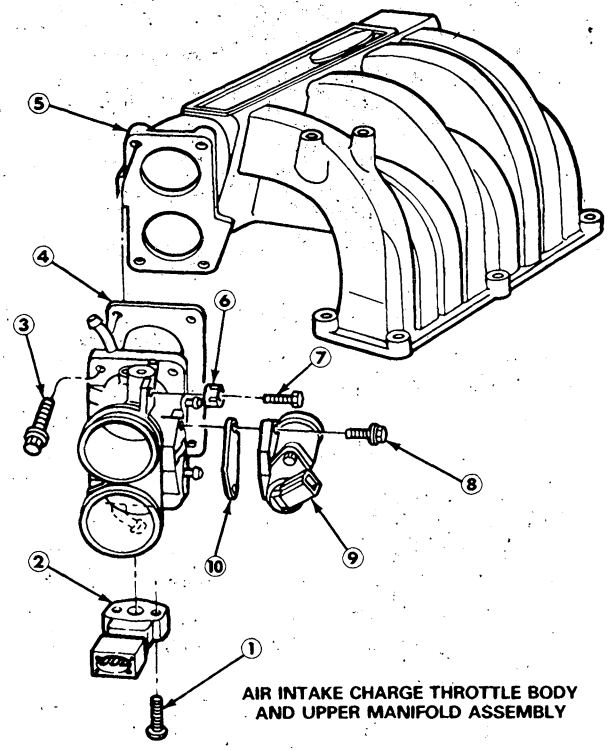


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DESCRIPTION AND OPERATION (Continued)

Air Throttle Body Assembly

The throttle body assembly controls airflow to the engine through a double butterfly-type valve. The throttle position is controlled by multiple-link, progressive opening, throttle linkage. The body is a single piece die casting made of aluminum. It has a dual bore with an air bypass channel around the throttle plate. This bypass channel controls both cold and warm engine idle airflow as regulated by an air bypass valve assembly mounted directly to the throttle body. The valve assembly is an electro-mechanical device controlled by the EEC computer. It incorporates a linear actuator which positions a variable area metering valve. Engine coolant is diverted through the throttle body mounting pad to improve cold weather operation.



AIR INTAKE CHARGE THROTTLE BODY AND UPPER MANIFOLD ASSEMBLY

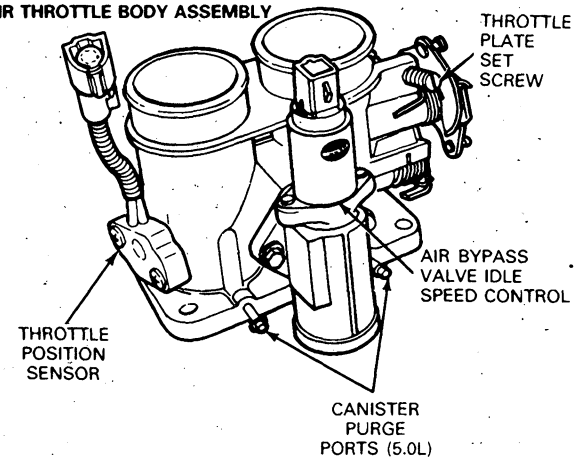
ITEM	PART NO.	PART NAME
1.	N803469-S100	SCREW AND WASHER ASSEMBLY - M4 x 22
2.	9B989	THROTTLE POSITION SENSOR
3.	56524-S8	BOLT - 5/16-18 x 1.25
4.	9E936	GASKET - AIR INTAKE CHARGE THROTTLE
5.	9424	MANIFOLD - INTAKE UPPER
6.	9C984	NUT - THROTTLE PLATE SET SCREW LOCKING
7.	390667-S2	SCREW - 10.32 BREAK-OFF HEAD
8.	N605773-S100	BOLT - M6 x 20
9.	9F715	AIR BYPASS VALVE ASSEMBLY
10.	9F670	GASKET - AIR BYPASS

V4789-1E

Other features of the air throttle body assembly include:

1. A preset stop to locate the WOT position.
2. A throttle body mounted throttle position sensor.
3. Canister purge port(s) (two on 5.0L, one on 5.8L) for evaporative emission control.

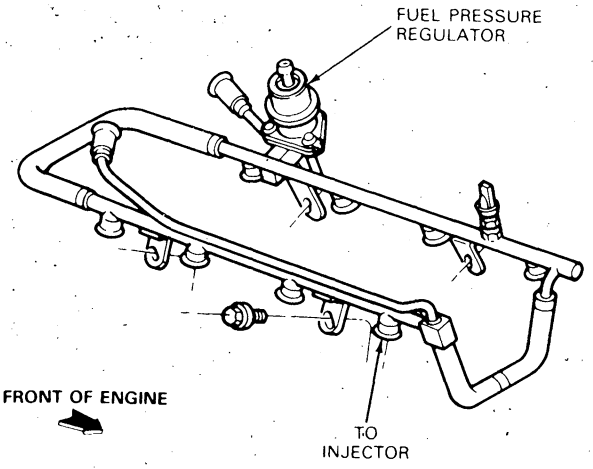
AIR THROTTLE BODY ASSEMBLY



V4762-1D

Fuel Supply Manifold Assembly

The fuel supply manifold assembly delivers high pressure fuel from the vehicle fuel supply line to the eight fuel injectors. The assembly consists of two banks of tubular fuel rails connected by two permanent crossover connections, eight injector connectors, a mounting flange to the fuel pressure regulator and mounting attachments which locate the fuel manifold assembly and provide fuel injector retention. The fuel inlet and outlet connections have push connect fittings. The unit is serviced as an assembly only.



V5301-1B

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REMOVAL AND INSTALLATION

Fuel Charging Assembly (Throttle Body, Upper and Lower Manifolds)

PRE-SERVICE PROCEDURES

The fuel charging assembly consists of the air throttle body, and the upper and lower intake manifolds. Prior to service or removal of the fuel charging assembly, the following steps must be taken:

1. Open hood and install protective covers.
2. Disconnect battery ground cable and secure it out of the way.
3. Remove fuel cap at tank to relieve pressure.
4. Release pressure from fuel system. A valve at the fuel rail is provided for this. Refer to Section 24-50, Fuel Tanks and Lines for Fuel System Pressure Relief procedures.

POST-SERVICE PROCEDURES

After the service is complete and the fuel charging assembly is installed to engine, the following steps must be taken:

1. Install fuel cap at tank.
2. Connect battery ground cable.
3. Add coolant, if it was removed.
4. Turn ignition switch on/off several times without starting engine to check for fuel leaks.

NOTE: Check all connections at fuel rails, push connect fittings, etc.

CAUTION: The fuel system is normally pressurized to 276 kPa (40 psi).

5. Start engine and warm to operating temperature. Check for coolant leak if coolant was removed.
6. Perform EEC-IV Self Test to check systems function. Refer to Engine/Emissions Diagnosis manual.*

Upper Intake Manifold and Throttle Body

Removal

1. Disconnect electrical connectors at air bypass valve, throttle position sensor and EGR position sensor.
2. Disconnect throttle linkage at throttle ball. Disconnect AOD (5.0L only) transmission linkage from throttle body. Remove two bolts securing throttle linkage bracket to intake. Position bracket with cables out of way.

CAUTION: When disconnecting throttle cable from ball stud, use a screwdriver or similar tool close to the stud and pry slowly. Pulling by hand may damage the cable.

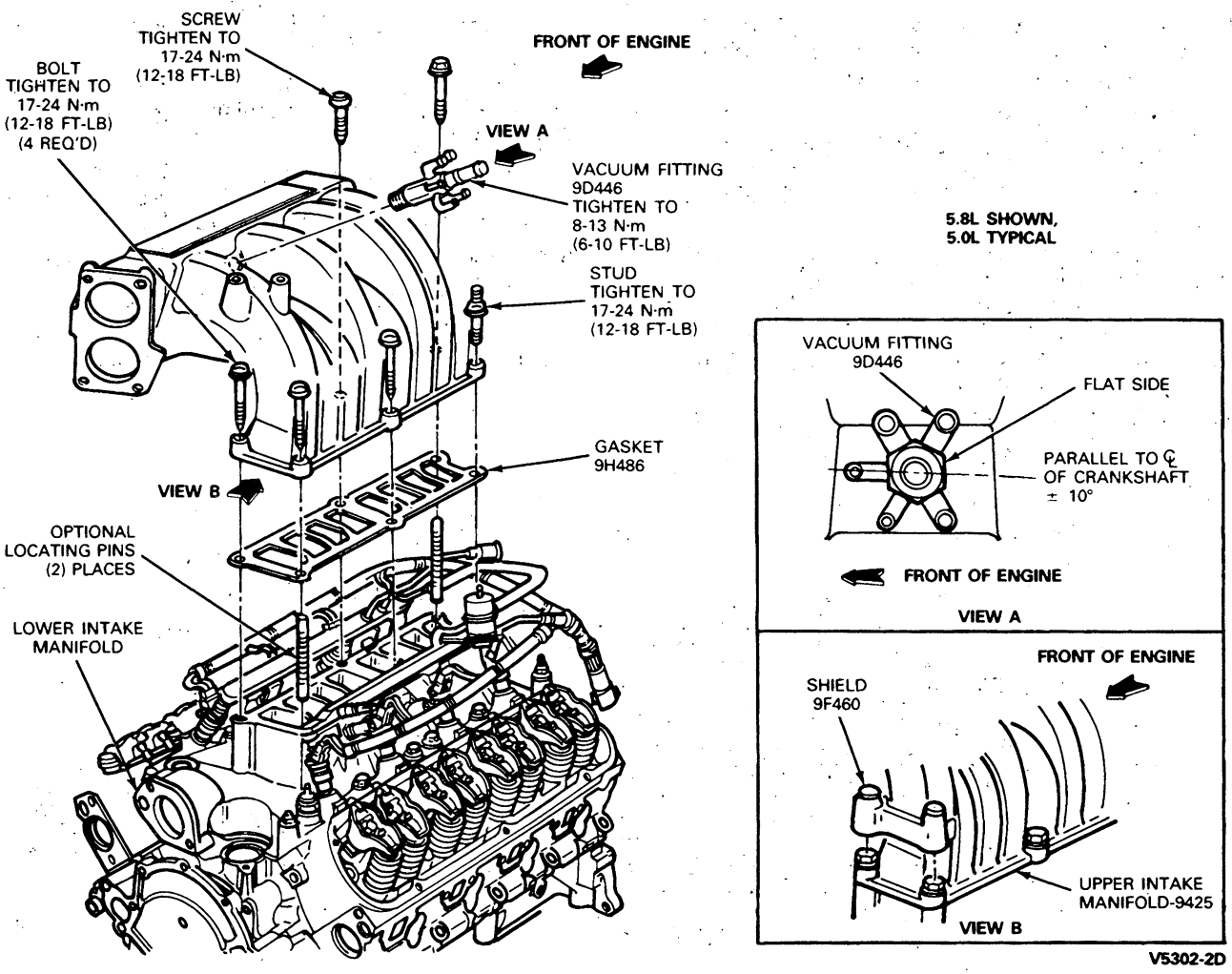
3. Disconnect upper intake manifold vacuum fitting connections by disconnecting all vacuum lines to vacuum tree, vacuum lines to EGR valve, and vacuum line to fuel pressure regulator.
4. Disconnect PCV system by disconnecting hose from fitting on rear of upper manifold.
5. Remove canister purge line(s) from fitting(s) on throttle body.
6. Disconnect water heater lines from the throttle body.
7. Disconnect EGR tube from EGR valve by removing flange nut.
8. Remove bolt from upper intake support bracket to upper manifold.
9. Remove six upper intake manifold retaining bolts.
10. Remove upper intake and throttle body as an assembly from lower intake manifold.

*Can be purchased as a separate item.

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REMOVAL AND INSTALLATION (Continued)

UPPER INTAKE MANIFOLD



Installation

1. Clean and inspect the mounting faces of the lower and upper intake manifolds.
2. Position new gasket on lower intake mounting face. The use of alignment studs may be helpful.
3. Install upper intake manifold and throttle body assembly to lower manifold making sure gasket remains in place (if alignment studs aren't used).
4. Install six upper intake manifold retaining bolts and tighten to specification.
5. Install upper intake support bracket to upper manifold attaching bolt.
6. Install EGR tube.
7. Install canister purge lines to fittings on throttle body.
8. Connect water heater lines to the throttle body.
9. Connect PCV hose to rear of upper manifold.
10. Connect vacuum lines to vacuum tree, EGR valve, and fuel pressure regulator.
11. Position throttle linkage bracket with cables to upper intake manifold. Install two attaching bolts and tighten to specification. Connect throttle cable and transmission cable to throttle body.
12. Connect electrical connectors at air bypass valve, TP sensor, and EGR position sensor.

NOTE: If lower intake manifold was removed, fill and bleed cooling system as outlined. Refer to Section 27-02, Cooling System Service.

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REMOVAL AND INSTALLATION (Continued)

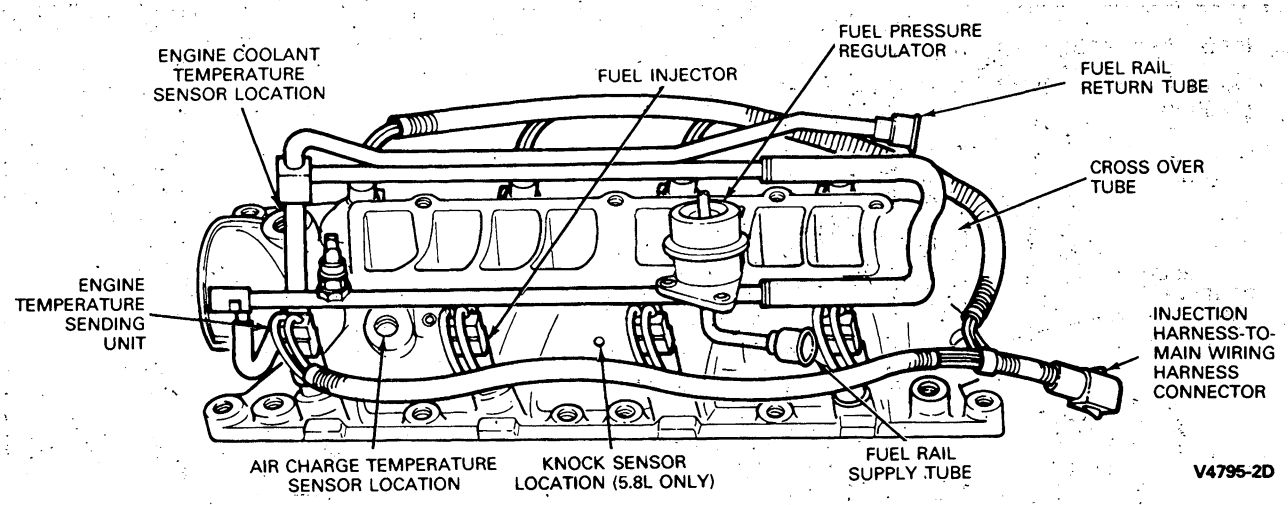
Lower Intake Manifold

Removal

1. Remove intake manifold/throttle body assembly and air cleaner assembly prior to lower intake manifold removal.
2. Drain cooling system.
3. Remove distributor assembly, cap and wires. Mark position of distributor and rotor during removal so that they can be installed in their original position.
4. Disconnect the electrical connections at the engine coolant temperature (ECT) sensor, engine temperature sending unit, air charge temperature (ACT) sensor, knock sensor (KS), electrical vacuum regulator (EVR) and Thermactor solenoids.
5. Disconnect the injector wiring harness from main harness assembly.
6. Remove EGO ground wire from intake manifold stud.

NOTE: The plated stud and ground wire must be installed in the same position as when it was removed.

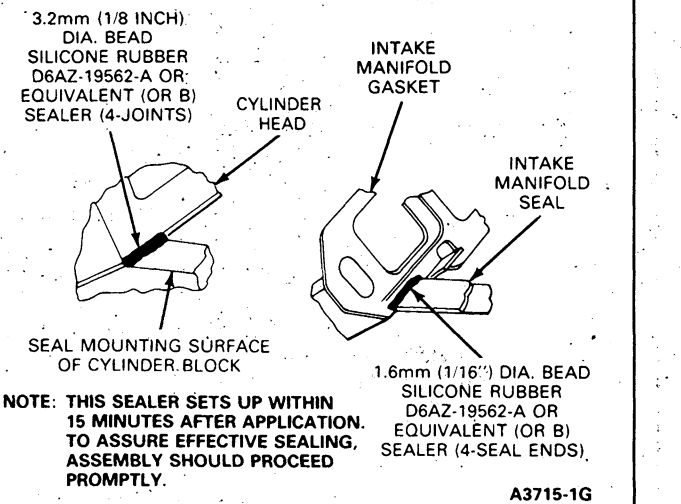
7. Release fuel system pressure. Refer to Section 24-50, Fuel Tank and Lines and Fuel Evaporative Emission Control System.
8. Disconnect fuel supply and return line retaining clips. Disconnect fuel supply and return lines from fuel rails, using Quick Disconnect Tool D87L-9280-A and D87L-9280-B or equivalent. Refer to fuel supply manifold assembly.



9. Remove upper radiator hose from thermostat housing.
10. Remove water bypass hose.
11. Remove heater outlet hose at intake manifold.
12. Remove nut securing coil bracket and move bracket out of way.
13. Remove intake attaching bolts and studs, noting location of studs and bolts.
14. Remove lower intake manifold assembly.

Installation

1. Clean and inspect the mounting faces of the lower intake cylinder heads and cylinder block surfaces. Refer to Section 21-21, 5.0L and 5.8L Engines.
2. Apply 1/16 inch bead of Silicone Rubber D6AZ-19562-A or equivalent, sealer to the end seals (junction).



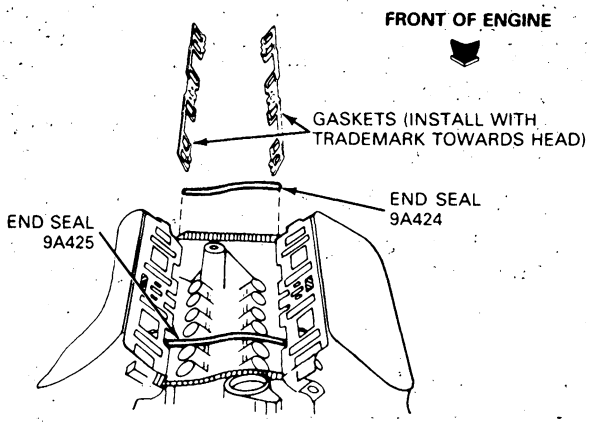
NOTE: THIS SEALER SETS UP WITHIN 15 MINUTES AFTER APPLICATION. TO ASSURE EFFECTIVE SEALING, ASSEMBLY SHOULD PROCEED PROMPTLY.

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REMOVAL AND INSTALLATION (Continued)

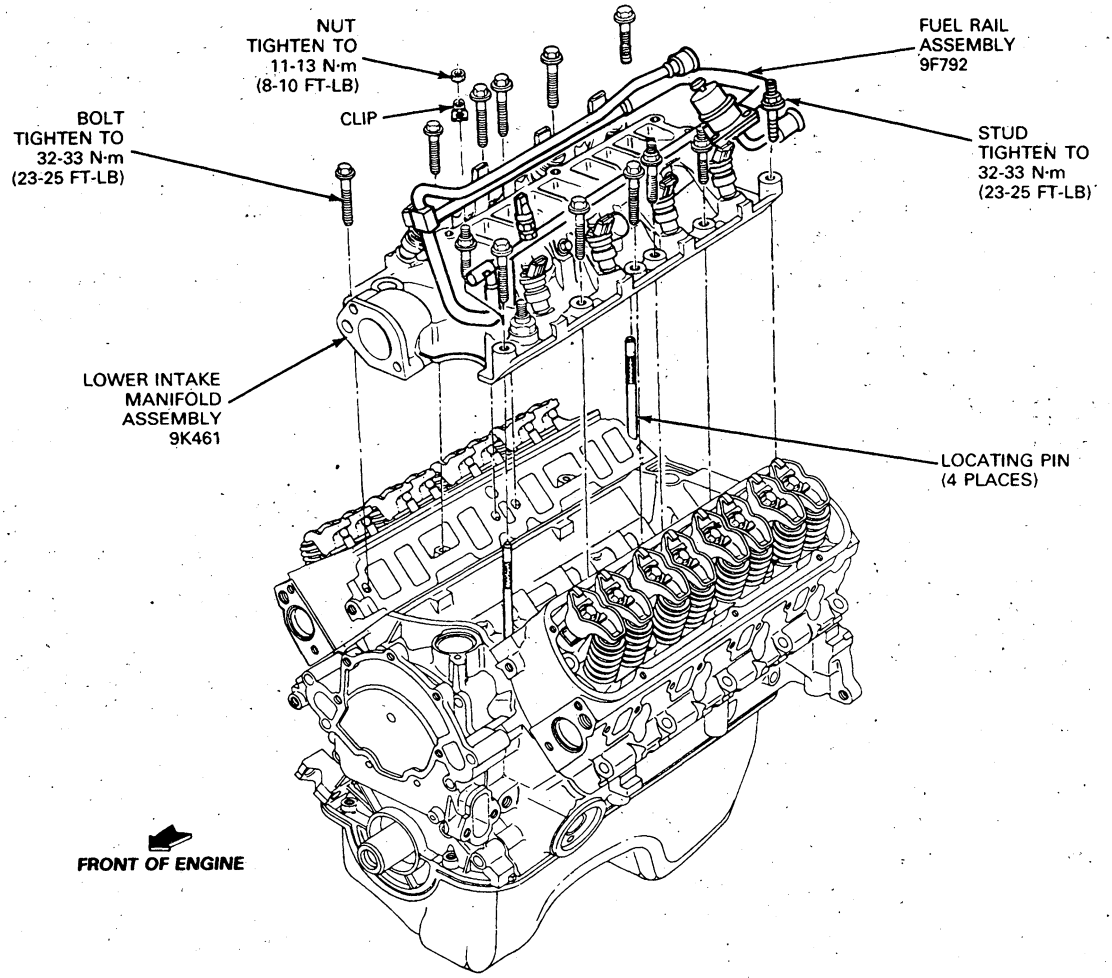
3. Install end seals on the cylinder block and new gaskets on the cylinder heads.

NOTE: The gaskets must be interlocked with the seal tabs.



V4793-1A

4. Install two locator pins into opposite corners.
5. Carefully lower intake manifold assembly into position.

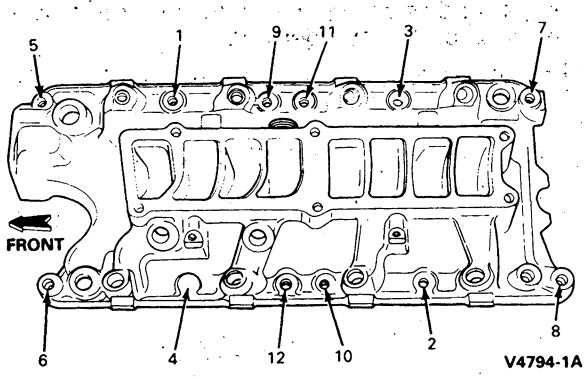


V4792-2D

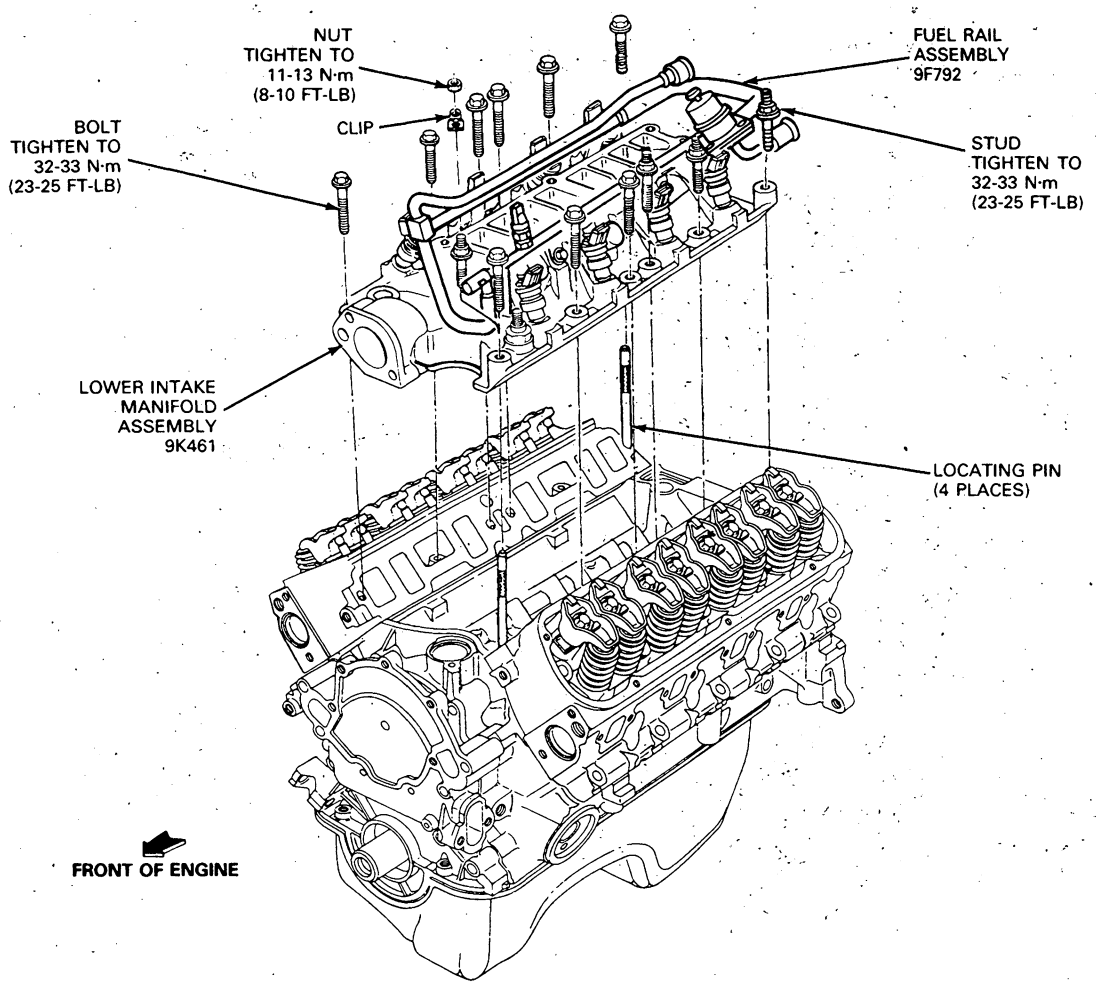
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REMOVAL AND INSTALLATION (Continued)

6. Install intake manifold bolts and studs. Tighten all bolts and studs in sequence to 30-43 N·m (22-32 ft-lb). Wait ten minutes then tighten all bolts and studs in sequence again to specification.
7. Position coil bracket and hold in place while tightening nut.
8. Install coil and solenoid bracket to intake manifold studs and exhaust manifold stud. Install attaching nuts and tighten to specification.



9. Install upper radiator hose and water bypass hose to thermostat housing.
10. Install heater outlet hose to intake manifold.
11. Connect fuel supply and return lines to fuel rails. These are push connect fittings. Connect fuel line retaining clips.
12. Connect the electrical connectors to engine coolant temperature (ECT) sensor, air charge temperature (ACT) sensor, engine temperature sender, knock sensor (KS, 5.0L), electrical vacuum regulator (EVR) and Thermactor solenoids.
13. Install distributor assembly in the proper position as noted during removal. Install distributor cap and wires.
14. Install upper intake manifold as outlined in this Section.
15. Fill and bleed the cooling system.



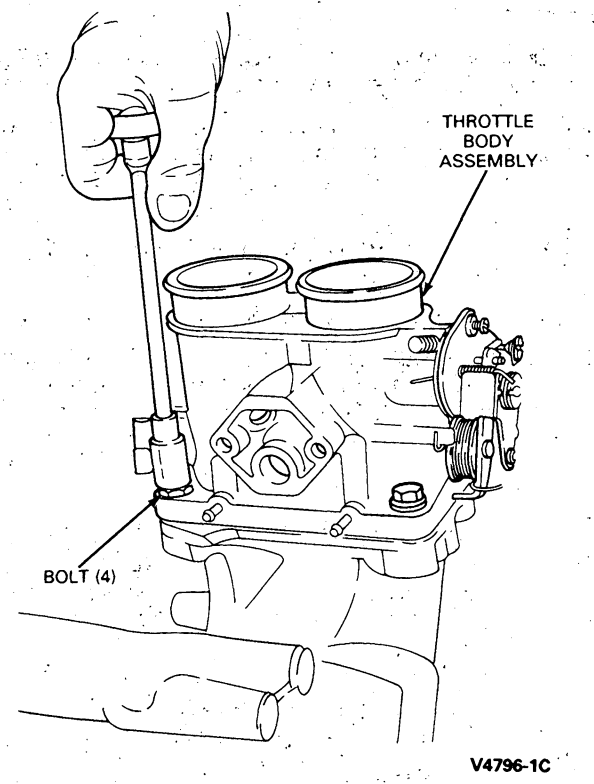
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REMOVAL AND INSTALLATION (Continued)

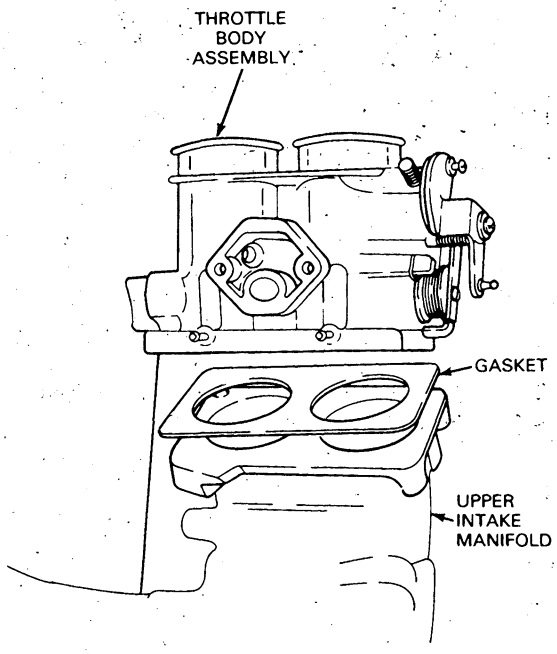
Air Intake Throttle Body

Removal

1. Disconnect throttle position sensor and air bypass valve connectors.
2. Remove four throttle body bolts.



3. Carefully separate air throttle body from upper intake manifold.
4. Remove and discard gasket between throttle body and upper intake manifold.



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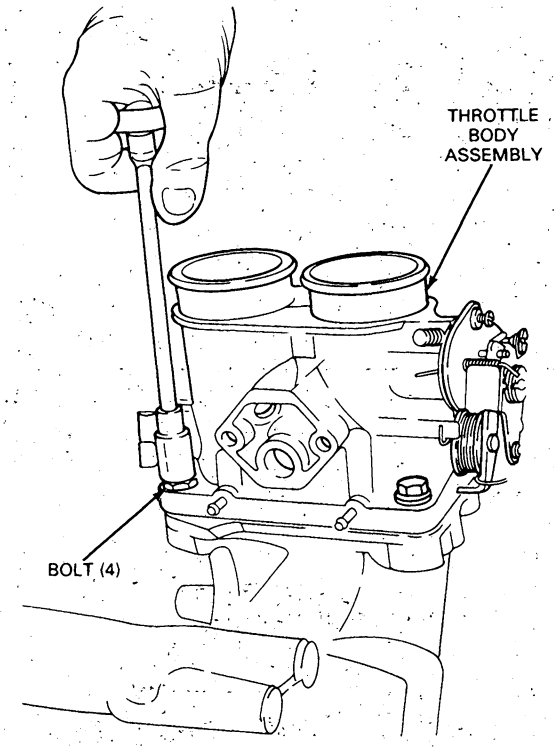
REMOVAL AND INSTALLATION (Continued)

Installation

1. Ensure that both throttle body and upper intake manifold gasket surfaces are clean.

NOTE: If scraping is necessary, be careful not to damage gasket surfaces of throttle body and upper manifold assemblies, or allow material to drop into manifold.

2. Install throttle body gasket on the four studs of the upper intake manifold.
3. Install throttle body to upper intake manifold.
4. Secure throttle body assembly to upper intake manifold with four retaining bolts. Tighten to 16-24 N·m (12-18 ft-lb).



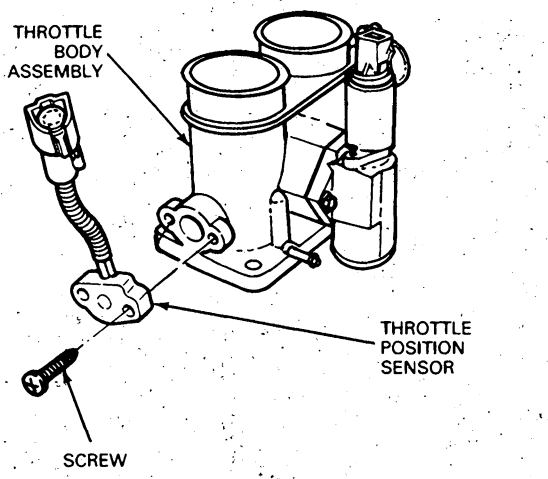
V4796-1C

5. Connect air bypass valve and throttle position sensor electrical connectors.

Throttle Position Sensor

Removal

1. Disconnect throttle position sensor from wiring harness.
2. Scribe a reference mark across the edge of the sensor and to the throttle body to ensure correct position during installation.



V4802-1C

3. Remove two throttle position sensor retaining screws.
4. Remove throttle position sensor.

Installation

1. Position the throttle position sensor so that the wiring harness is parallel to the venturi bores. Then, rotate throttle position sensor clockwise to align scribe marks.
2. Secure sensor to throttle body assembly with two retaining screws. Tighten to 2.0-3.0 N·m (18-26.5 lb-in).
3. Connect electrical connector to harness.
4. Adjust throttle position sensor as described in Section 3 of the Engine/Emission Diagnosis manual*.

*Can be purchased as a separate item.

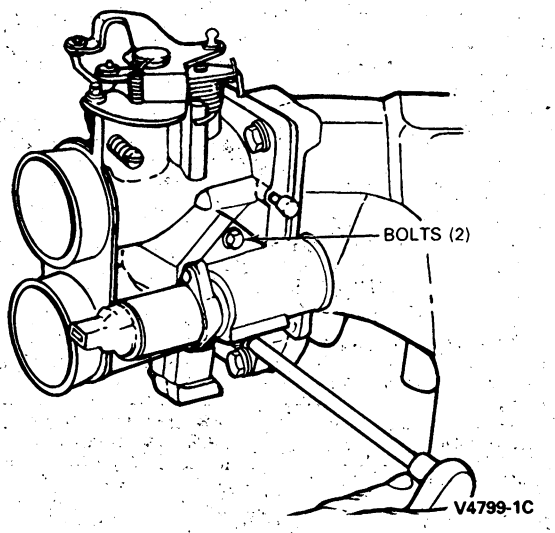
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REMOVAL AND INSTALLATION (Continued)

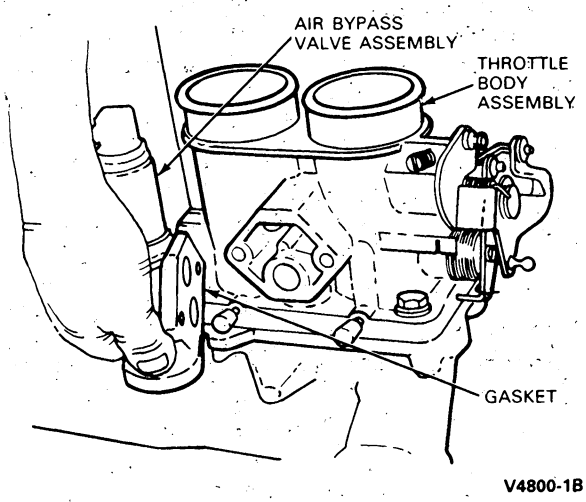
Air Bypass Valve Assembly

Removal

1. Disconnect the air bypass valve assembly connector from the wiring harness.
2. Remove the two air bypass valve retaining bolts.



3. Remove the air bypass valve and gasket.

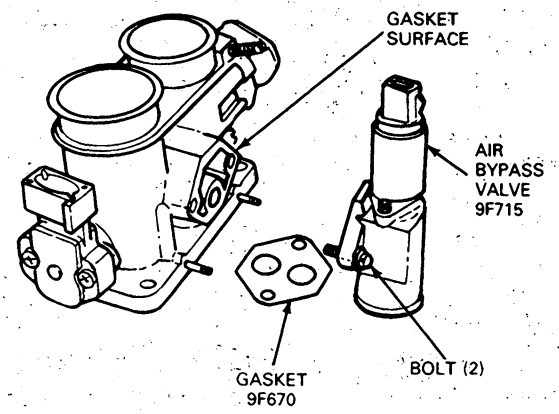


Installation

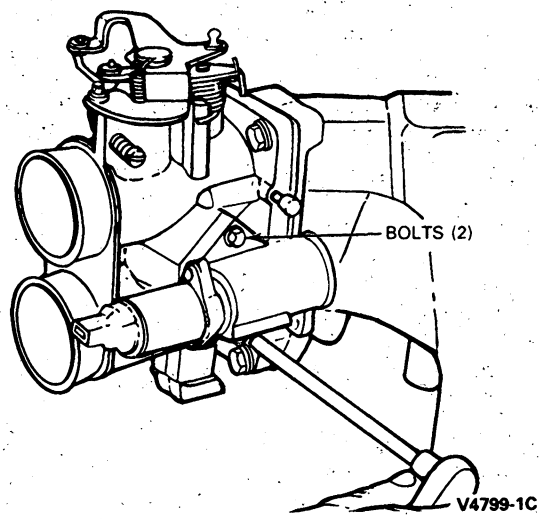
1. Ensure that both throttle body and air bypass valve gasket surfaces are clean.

NOTE: If scraping is necessary, be careful not to damage air bypass valve or throttle body gasket surfaces, or drop material into throttle body.

2. Install gasket and air bypass valve on throttle body surfaces.



3. Install retaining screws. Tighten to 8-11 N·m (71-102 lb-in).
4. Connect electrical connector for the air bypass valve.



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REMOVAL AND INSTALLATION (Continued)

Fuel Supply Manifold Assembly

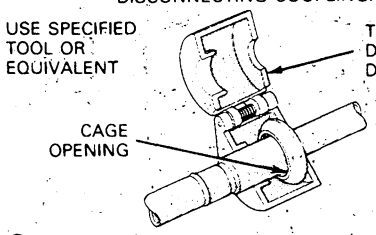
Removal

1. Perform Steps 1-4 under Fuel Charging Assembly.
2. Remove upper manifold assembly as outlined in this Section.
3. Relieve the fuel pressure. Refer to Section 24-50, Fuel Tank and Lines and Fuel Evaporative Emission Control System.
4. Disconnect fuel supply and return line retaining clips.
5. Using Quick Disconnect Tool D87L-9280-A or D87L-9280-B or equivalents, disconnect the fuel chassis inlet and outlet fuel hoses from the fuel supply manifold.

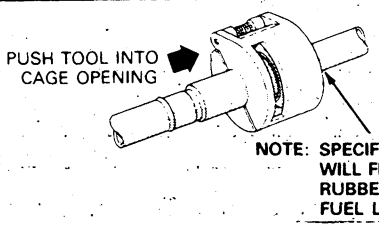
FUEL LINE SPRING LOCK COUPLING

TO DISCONNECT COUPLING

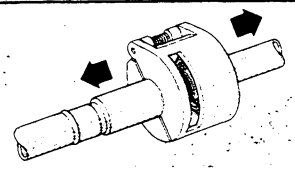
CAUTION – RELIEVE FUEL PRESSURE BEFORE DISCONNECTING COUPLING.



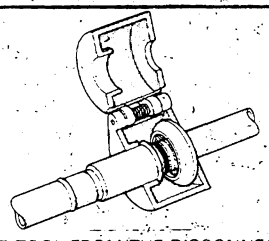
① FIT TOOL TO COUPLING SO THAT TOOL CAN ENTER CAGE OPENING TO RELEASE THE GARTER SPRING.



② PUSH THE TOOL INTO THE CAGE OPENING TO RELEASE THE FEMALE FITTING FROM THE GARTER SPRING.

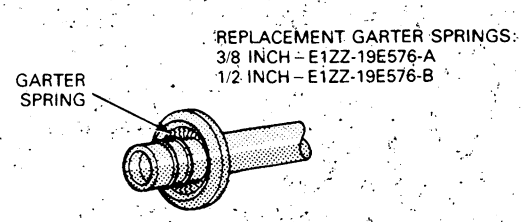


③ PULL THE COUPLING MALE AND FEMALE FITTINGS APART.

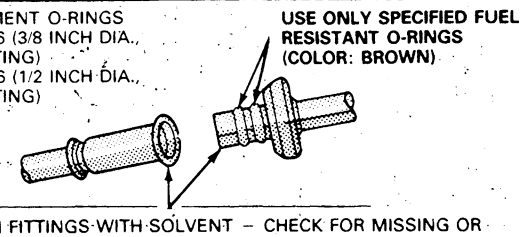


④ REMOVE THE TOOL FROM THE DISCONNECTED SPRING LOCK COUPLING.

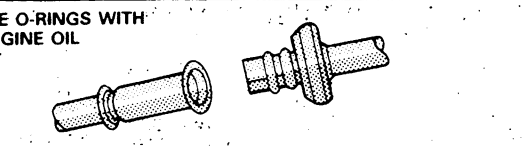
TO CONNECT COUPLING



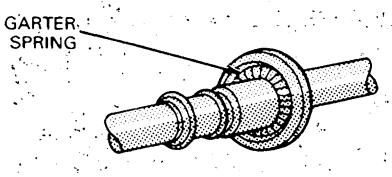
① CHECK FOR MISSING OR DAMAGED GARTER SPRING – REMOVE DAMAGED SPRING WITH SMALL HOOKED WIRE – INSTALL NEW SPRING.



② CLEAN FITTINGS WITH SOLVENT – CHECK FOR MISSING OR DAMAGED O-RINGS. REPLACE MISSING O-RINGS. IF **EITHER** O-RING IS DAMAGED, REPLACE **BOTH** O-RINGS.



③ ASSEMBLE FITTING BY PUSHING WITH A SLIGHT TWISTING MOTION.



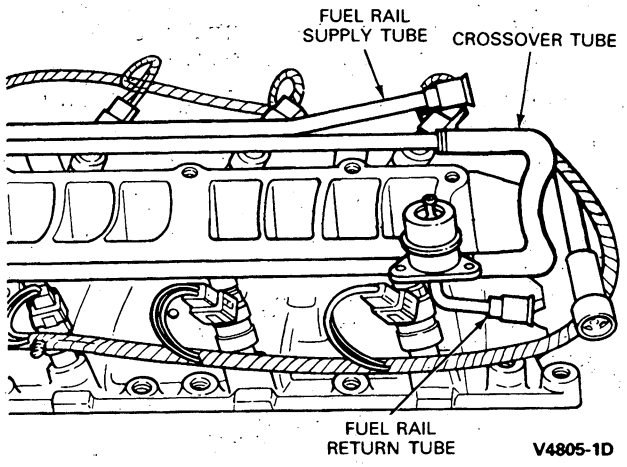
④ TO ENSURE COUPLING ENGAGEMENT, PULL ON FITTING AND VISUALLY CHECK TO BE SURE GARTER SPRING IS OVER FLARED END OF FEMALE FITTING.

V5937-2A

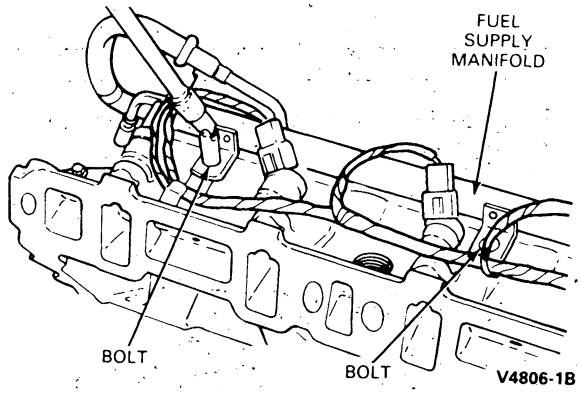
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REMOVAL AND INSTALLATION (Continued)

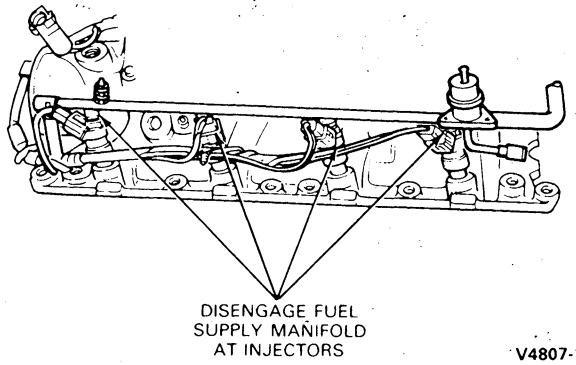
5. Disconnect the fuel supply and return line connections at the fuel supply manifold. Refer to Section 24-50, Fuel Tanks and Lines, for Push Connect Fitting Removal procedures.



6. Remove four (two per group) fuel supply manifold retaining bolts.

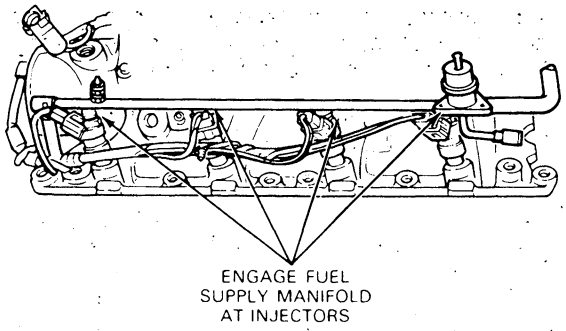


7. Carefully disengage manifold from fuel injectors and remove manifold.

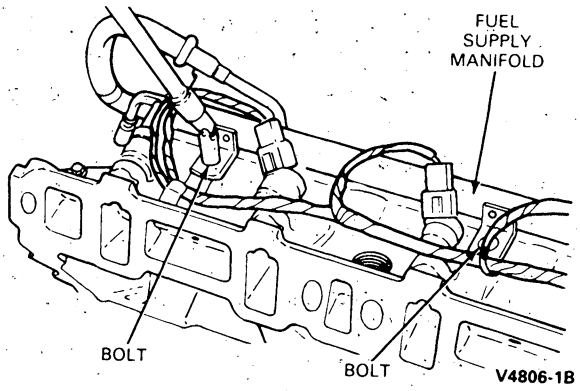


Installation

1. Ensure injector caps are clean and free of contamination.
2. Place the fuel injector fuel supply manifold over each of the injectors and seat injectors into fuel supply manifold. Make sure the injectors are well seated in the fuel manifold assembly.



3. Secure the fuel manifold assembly using four retaining bolts. Tighten to 20-30 N·m (15-22 ft-lb).



4. Connect the fuel inlet and outlet lines at the fuel rail connections. Push in to connect. Refer to illustration under Fuel Supply Manifold Assembly, Removal. Connect fuel line retaining clips.
5. Install upper intake manifold as outlined in this Section.

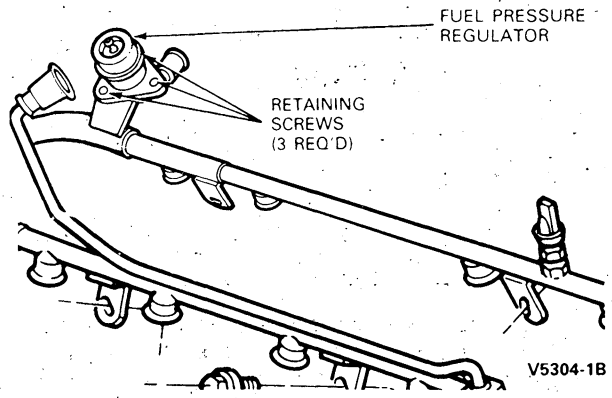
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REMOVAL AND INSTALLATION (Continued)

Fuel Pressure Regulator

Removal

1. Perform Steps 1-4 under Fuel Charging Assembly Pre-Service Procedures if removing fuel pressure regulator while fuel supply manifold is installed on engine.
2. Remove vacuum line at pressure regulator.
3. Remove three Allen retaining screws from regulator housing.
4. Remove pressure regulator assembly, gasket and O-ring. Discard gasket and inspect O-ring for signs of cracks or deterioration.
5. If scraping is necessary, be careful not to damage fuel pressure regulator or fuel supply line gasket surfaces.



Installation

1. Lubricate fuel pressure regulator O-ring with light oil ESF-M6C2-A or equivalent.

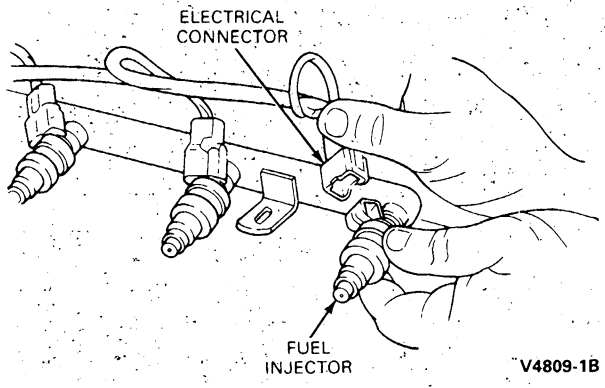
CAUTION: Never use silicone grease. It will clog the injectors.

2. Ensure gasket surfaces of fuel pressure regulator and fuel injector manifold are clean.
3. Install O-ring and new gasket on regulator.
4. Install fuel pressure regulator on injector manifold. Tighten three retaining screws to 3.0-4.5 N·m (27-40 in-lb).
5. Install vacuum line to regulator.
6. Perform Steps 1-5 under Fuel Charging Assembly Post Service Procedure.

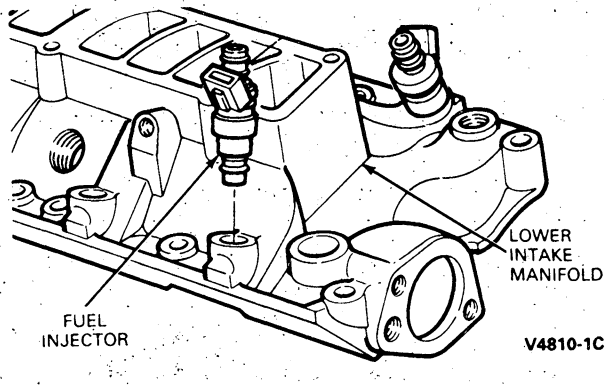
Fuel Injector

Removal

1. Perform Steps 1-4 under Fuel Charging Assembly Pre-Service Procedures.
2. Carefully remove electrical harness connectors from individual injectors as required.
3. Remove upper intake manifold as outlined in this Section.



4. Grasping injector body, pull up while gently rocking injector from side-to-side.

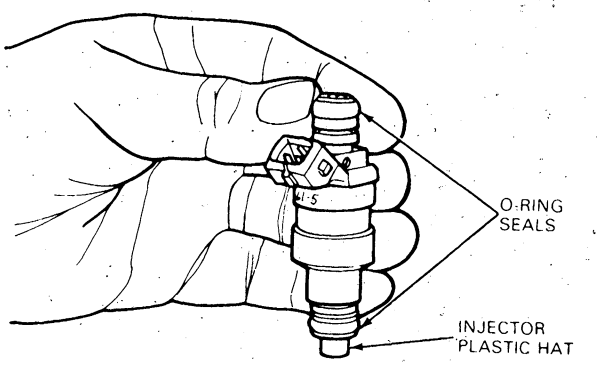


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REMOVAL AND INSTALLATION (Continued)

5. Inspect injector O-rings (two per injector) for signs of deterioration. Replace as required.

CAUTION: Do not attempt to clean the injector pintle or metering orifice with tools or brushes. Use Rotunda Injector Cleaner/Tester 113-00001 or equivalent.



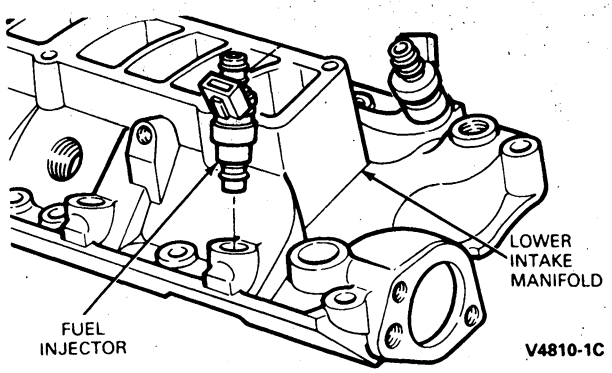
V5040-1A

Installation

1. Lubricate new O-rings with light grade oil ESF-M6C2-A or equivalent and install two on each injector.

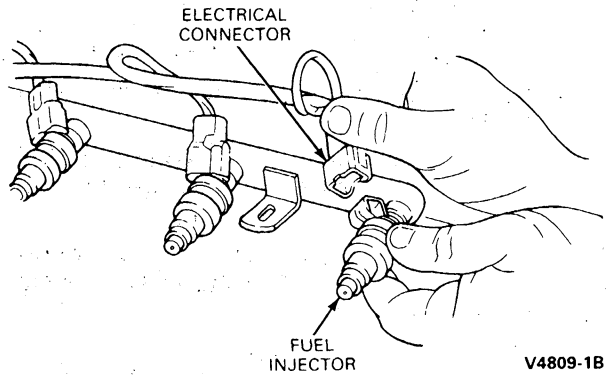
CAUTION: Never use silicone grease. It will clog the injectors.

2. Install injector(s) using light, twisting, pushing motion.
3. Install fuel supply manifold as outlined in this Section.



V4810-1C

4. Install electrical harness connectors to injectors.
5. Install upper intake manifold as outlined in this Section. Perform Steps 1-4 of Fuel Charging Assembly Pre-Service Procedures.



V4809-1B

SPECIFICATIONS

TORQUE SPECIFICATIONS

Description	N·m	Ft-Lb
Lower Intake Manifold to Head	30-43	22-32
EGR Tube	33.8-47.5	25-35
EGR Valve to Upper Intake Manifold	17-25	13-19
Cooling Manifold	4-5.6	35-50 in-lb
Upper Intake Manifold to Lower Intake Manifold Bolts	16.2-24.4	12-18
Throttle Body to Upper Intake Manifold	16-24	12-18
Air Bypass Valve to Throttle Body	8-11	71-102 in-lb
Throttle Position Sensor to Throttle Body	2.0-3.0	18-26.5 in-lb
Fuel Pressure Regulator to Injector Manifold	3-4.5	27-40 in-lb
Fuel Injector Manifold to Fuel Charging Assembly	16-20	12-15
Coil Bracket to Manifold Stud	5.9-7.4	52-65 in-lb
Throttle Cable Bracket to Manifold	11-13	8-10
Air Door Bracket to A/C Cleaner	7.9-11.2	70-100 in-lb

CV4866-1E

SPECIAL SERVICE TOOLS

SPECIAL SERVICE TOOLS

Tool Number	Description
D87L-9280-B	Spring Lock Coupling Remover 1/2 Inch
D87L-9280-A	Spring Lock Coupling Remover 3/8 Inch
T80L-9974-B	EFI Fuel Pressure Test Gauge

CV4867-1C

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SPECIAL SERVICE TOOLS (Continued)

ROTUNDA EQUIPMENT

Tool Number	Description
113-00001	Injector Cleaner/Tester

CV5945-1A

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SECTION 24-10 Electronic Fuel Injection—4.9L EFI Engine

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Components	24-10-3
Fuel Pressure Regulator	24-10-4
Fuel Supply Manifold Assembly	24-10-5
Intake Manifold	24-10-5
REMOVAL AND INSTALLATION	
Air Bypass Valve Assembly	24-10-19
Air Intake Throttle Body	24-10-17
Assembly and Disassembly	24-10-13
Fuel Charging Assembly—9973A	24-10-6

SUBJECT	PAGE
REMOVAL AND INSTALLATION (Cont'd.)	
Fuel Injection Wiring Harness	24-10-24
Fuel Injector	24-10-24
Fuel Pressure Regulator—9C968	24-10-23
Fuel Supply Manifold Assembly	24-10-20
Pressure Relief Valve—9H321	24-10-23
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Upper Intake Manifold and Throttle Body Assembly—9424AUP	24-10-13
SPECIFICATIONS	24-10-26
VEHICLE APPLICATION	24-10-1

VEHICLE APPLICATION

4.9L EFI Engine Truck Models.

DESCRIPTION AND OPERATION

The Electronic Fuel Injection system (EFI) is classified as a multi-point, pulse time, speed density, fuel injection system. Fuel is metered into the intake air stream in accordance with engine demand through six injectors mounted on a tuned intake manifold.

An onboard vehicle electronic engine control (EEC-IV) computer accepts inputs from various engine sensors to compute the required fuel flow rate necessary to maintain a prescribed air/fuel ratio throughout the entire engine operational range. The computer then outputs a command to the fuel injectors to meter the required quantity of fuel.

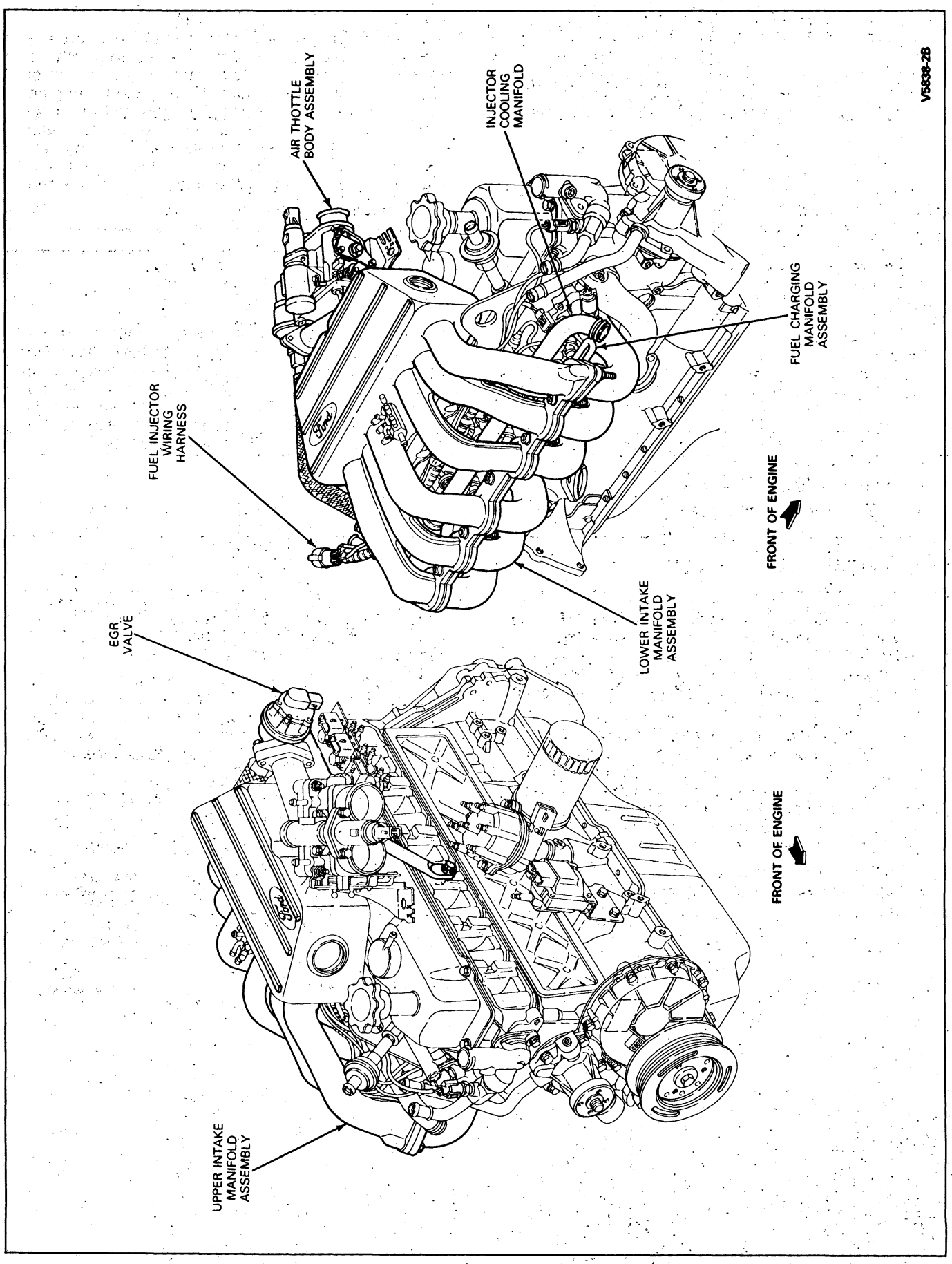
The EEC-IV engine control system will automatically sense and compensate for changes in altitude (e.g., from sea level to mountains) and will also permit push-starting the vehicle should it become necessary (manual transmission only).

The fuel delivery subsystem consists of a low pressure in-tank mounted fuel pump, a fuel reservoir and a high pressure, chassis-mounted, electric fuel pump, delivering fuel from the fuel tank through a 20 micron fuel filter to a fuel charging manifold assembly.

The fuel charging manifold assembly incorporates electrically actuated fuel injectors directly above each of the engine's six intake ports. The injectors, when energized, spray a metered quantity of fuel into the intake air stream.

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DESCRIPTION AND OPERATION (Continued)



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DESCRIPTION AND OPERATION (Continued)

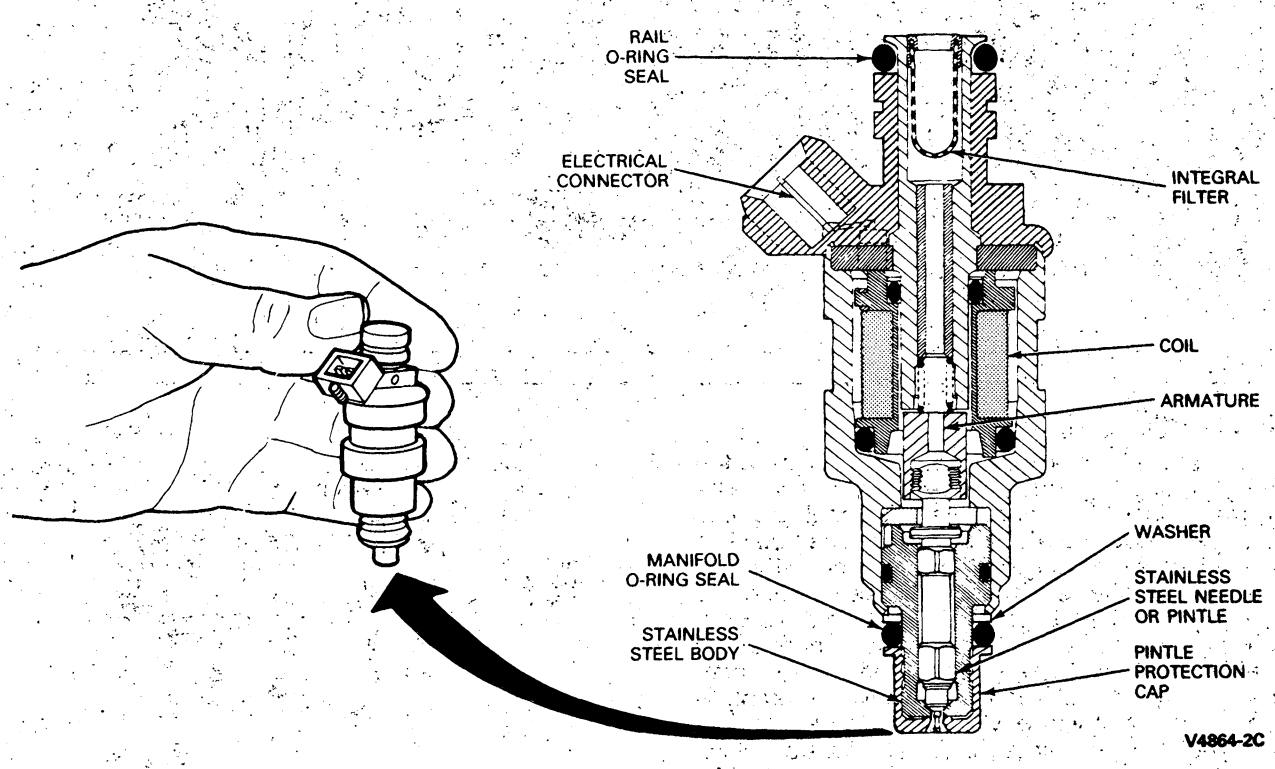
A constant fuel pressure drop is maintained across the injector nozzles by a pressure regulator which is positioned downstream from them. Excess fuel supplied by the pump, but not required by the engine, passes through the regulator and returns to the fuel tank through a fuel return line.

The injectors are energized in two banks of three injectors, 1-3-5 in one bank and 2-4-6 in the other, with one bank energized every crankshaft revolution. The period of time that the injectors are energized (injector "on time" or pulse width) is controlled by the vehicle's electronic engine control (EEC-IV) computer. Input from various engine sensors is used to compute the required fuel flow rate necessary to maintain a prescribed air/fuel ratio for the given engine operation. The computer determines the needed injector pulse width and outputs a command to the injector to meter the exact quantity of fuel.

Components

Fuel Injectors

The six fuel injector nozzles are electro-mechanical devices which both meter and atomize fuel delivered to the engine. The injectors are mounted in the lower intake manifold and are positioned so that their tips direct fuel just ahead of the engine intake valves. The injector body consists of a solenoid-actuated pintle and needle and valve assembly. An electrical control signal from the electronic engine control computer activates the injector solenoid, causing the pintle to move upward off the seat, allowing fuel to flow. Since the injector flow orifice is fixed and the fuel pressure drop across the injector tip is constant, fuel flow to the engine is regulated by how long the solenoid is energized. Atomization is obtained by contouring the pintle at the point where the fuel separates.

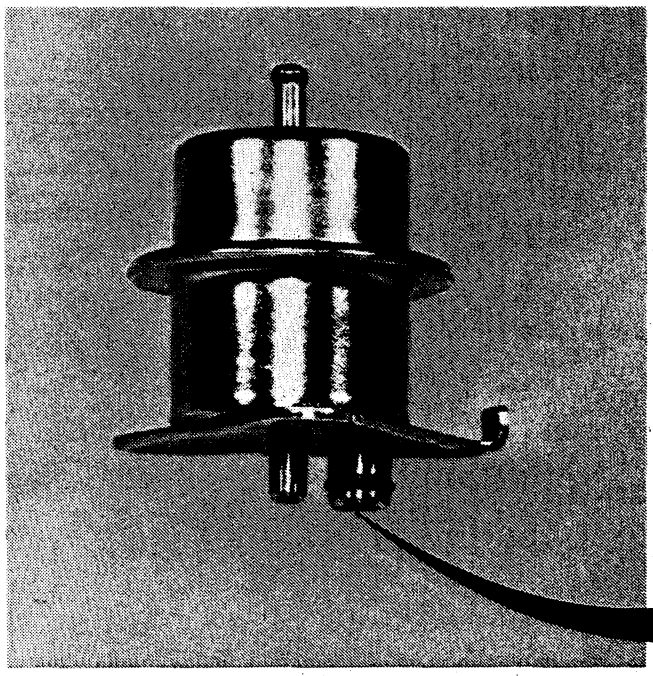


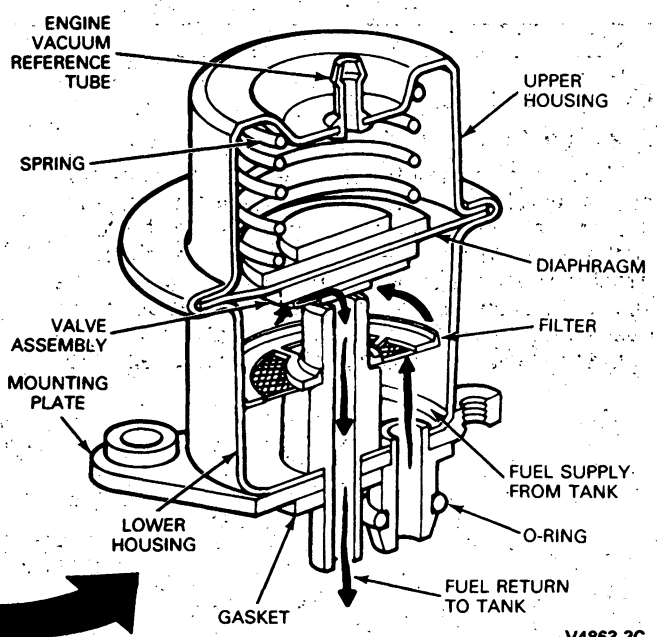
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DESCRIPTION AND OPERATION (Continued)

Fuel Pressure Regulator

The fuel pressure regulator is attached to the fuel supply manifold assembly downstream of the fuel injectors. It regulates the fuel pressure supplied to the injectors. The regulator is a diaphragm-operated relief valve in which one side of the diaphragm senses fuel pressure and the other side is subjected to intake manifold vacuum. The nominal fuel pressure is established by a spring preload applied to the diaphragm. Balancing one side of the diaphragm with manifold vacuum maintains a constant fuel pressure drop across the injectors. Fuel, in excess of that used by the engine, is passed through the regulator and returns to the fuel tank.

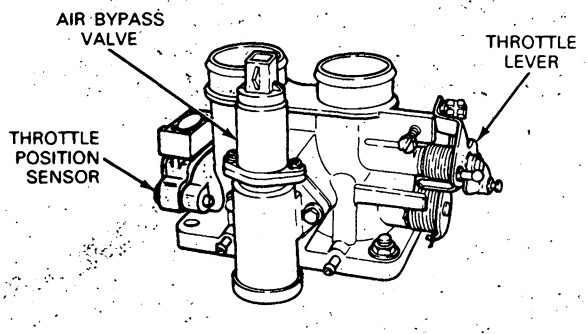




V4863-2C

Air Throttle Body Assembly

The throttle body assembly controls airflow to the engine through a double butterfly-type valve. The throttle position is controlled by multiple-link, progressive opening, throttle linkage. The body is a single piece die casting made of aluminum. It has a dual bore with an air bypass channel around the throttle plate. This bypass channel controls both cold and warm engine idle airflow control as regulated by an air bypass valve assembly mounted directly to the throttle body. The valve assembly is an electro-mechanical device controlled by the EEC computer. It incorporates a linear actuator which positions a variable area metering valve. The idle speed screw engages the secondary throttle lever for AOD transmissions, and engages the primary throttle lever for C-6 and manual transmissions.



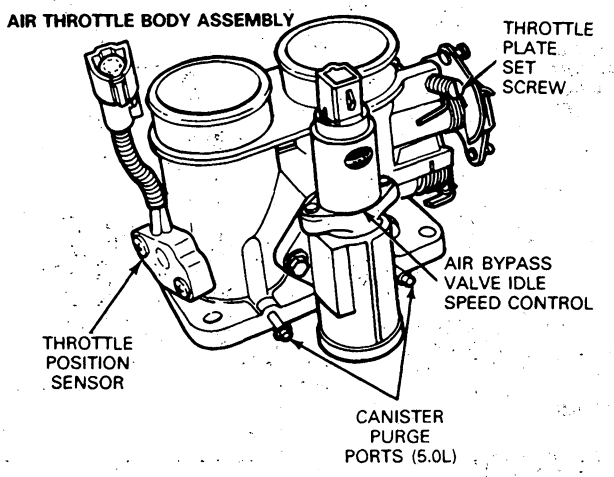
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DESCRIPTION AND OPERATION (Continued)

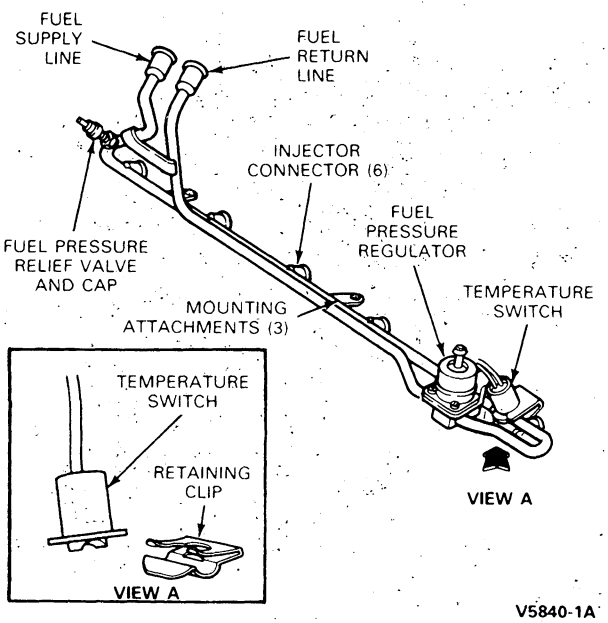
Other features of the air throttle body assembly include:

1. A preset stop to locate the WOT position.
2. A throttle body mounted throttle position sensor.
3. Canister purge ports (2) for evaporative emission control.



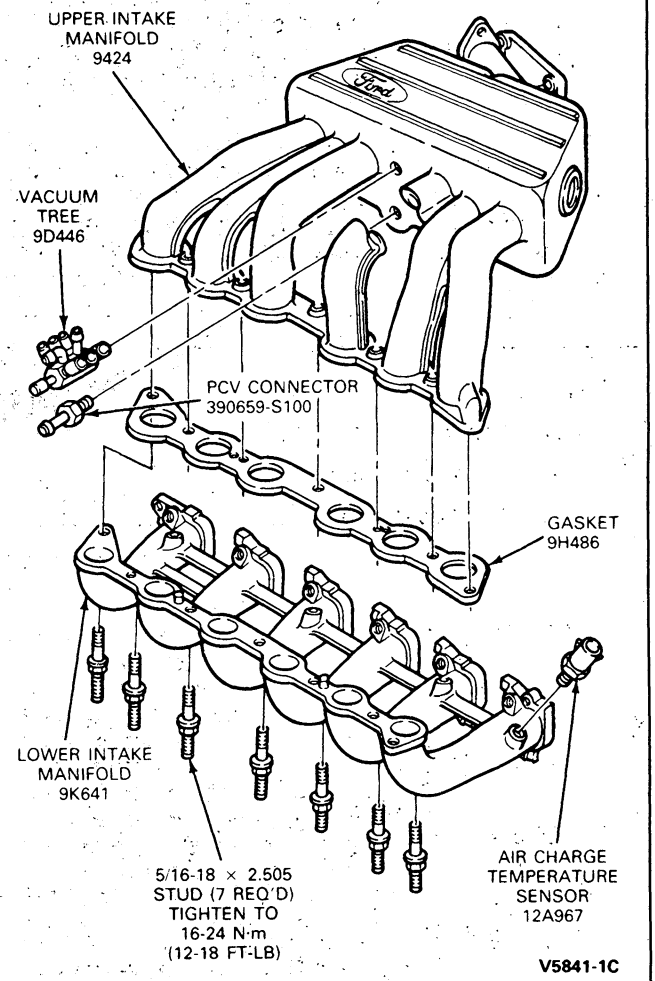
Fuel Supply Manifold Assembly

The fuel supply manifold assembly delivers high pressure fuel from the vehicle fuel supply line to the six fuel injectors. The assembly consists of a pre-formed tube for fuel supply and one for fuel return. The fuel pressure manifold assembly has six injector connectors, a mounting flange for the fuel pressure regulator, and mounting attachments which locate the fuel manifold assembly and provide fuel injector retention. The manifold also is equipped with a fuel pressure relief valve on the fuel supply tube.



Intake Manifold

The intake manifold is a two-piece (upper and lower intake manifold) aluminum casting. Runner lengths are tuned to optimize engine torque and power output. The manifold provides mounting flanges for the air throttle body assembly, fuel supply manifold, accelerator control bracketry and the EGR valve and supply tube. A vacuum fitting is installed to provide vacuum to various engine accessories. Pockets for the fuel injectors are machined to prevent both air and fuel leakage. The pockets in which the injectors are mounted are placed to direct the injector fuel spray immediately in front of each engine intake valve.



ADJUSTMENTS, DIAGNOSIS AND TESTING

Refer to the Engine/Emission Diagnosis manual.*

*Can be purchased as a separate item.

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REMOVAL AND INSTALLATION

Fuel Charging Assembly—9973A

Pre-Service Procedures

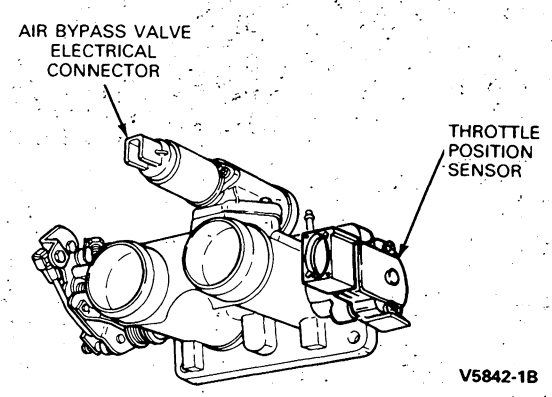
NOTE: If subassemblies are to be serviced and/or removed with the fuel charging assembly mounted on the engine, the following steps must be taken:

1. Open hood and install protective covers.
2. Ensure ignition is in OFF position.
3. Disconnect battery ground cable and secure it out of the way.
4. Remove fuel filler cap to relieve fuel tank pressure.
5. Release pressure from fuel system at the fuel pressure relief valve using EFI Pressure Gauge T80L-9974-B or equivalent. The fuel pressure relief valve is located on the fuel line in the upper RH corner of the engine compartment. To gain access to the fuel pressure relief valve, the valve cap must first be removed.

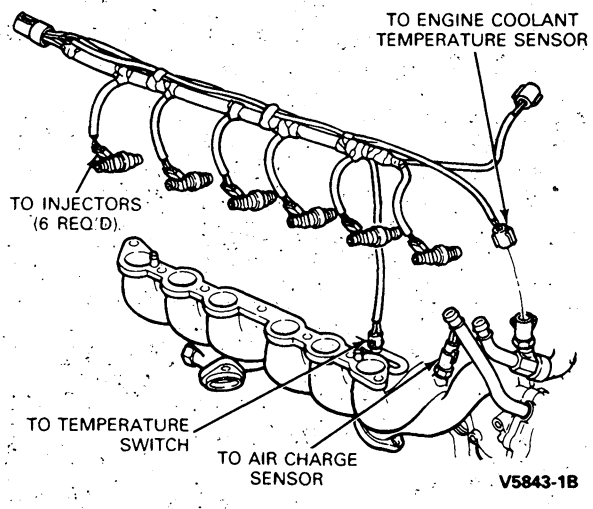
NOTE: Not all assemblies may be serviceable while on the engine. In some cases, removal of the fuel charging assembly may ease service of the various subassemblies. To remove the entire fuel charging assembly, the following procedure should be performed.

Removal

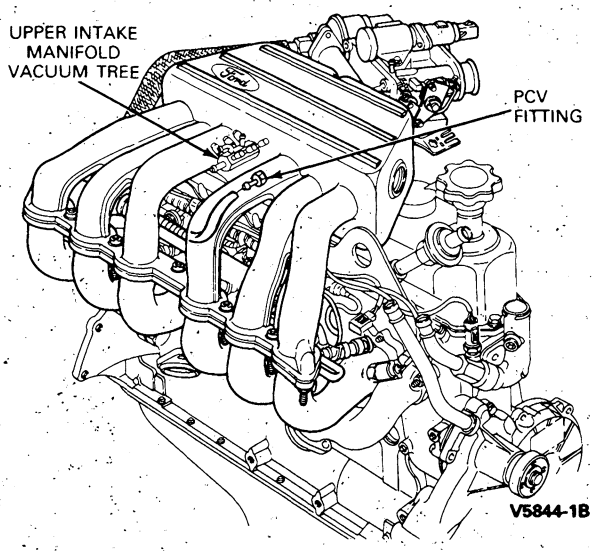
1. Disconnect electrical connectors at:
   a. Throttle position sensor.
   b. Air bypass valve.



   c. EVP sensor, located on the EGR valve.
   d. Injector wiring harness to main engine harness.
   e. Engine coolant temperature sensor.



2. Disconnect the following vacuum connections:
   a. Vacuum line at the EGR valve.
   b. Vacuum lines at the thermactor air bypass valve.
   c. Sealed Housing Evaporative Determination System (S.H.E.D.) evap lines to the throttle body.
   d. Vacuum line at the fuel pressure regulator.
   e. Vacuum lines to the upper intake manifold vacuum tree. Labeling the hose locations with tape is recommended to aid installation.



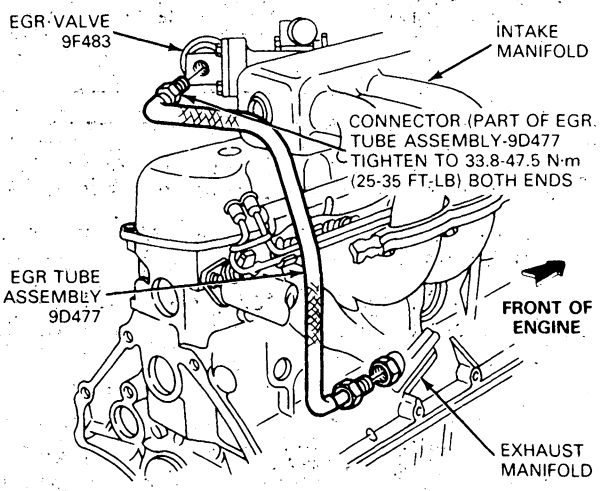
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REMOVAL AND INSTALLATION (Continued)

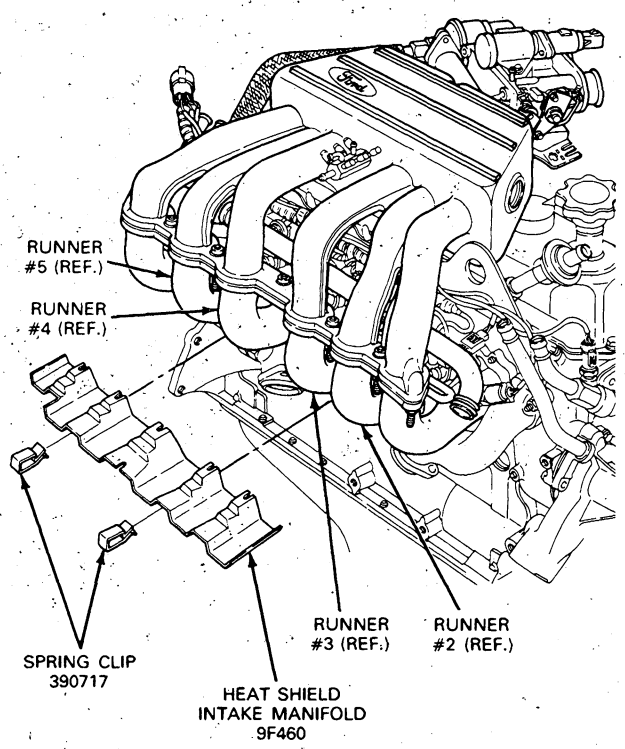
3. Disconnect the PCV hose from the fitting, located on the underside of the upper intake manifold.
4. Remove the throttle linkage shield, and disconnect the throttle linkage and speed control cables. Unbolt the accelerator cable from the bracket and position the cable away from the engine.

CAUTION: When disconnecting throttle cable from ball stud, use a screwdriver or similar tool close to the ball stud to pry off. Removing by hand may damage the cable.

5. Disconnect the air inlet hoses from the throttle body.
6. Disconnect the EGR tube from the EGR valve and the rear exhaust manifold. Remove the tube from the engine.



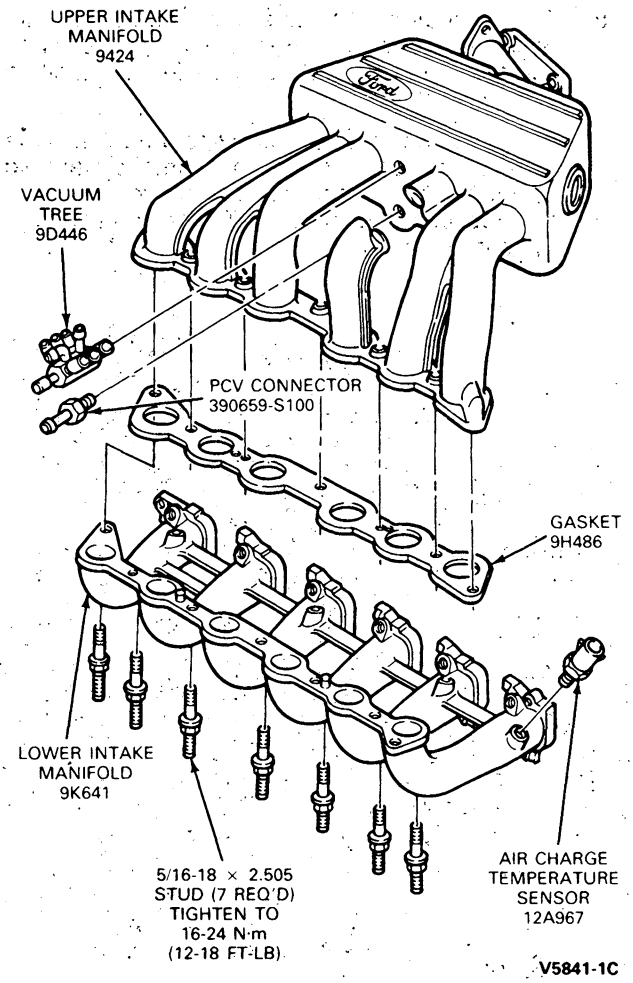
7. Remove the Thermactor tube assembly from the lower intake manifold by removing the two nuts retaining the tube. Remove the nut which attaches the Thermactor bypass valve bracket to the lower intake manifold.
8. For E-series applications only, remove the nut which attaches the transmission fill tube. Then remove the tube bracket off the intake manifold stud.
9. Remove the two spring clips attaching the injector heat shield to the lower intake manifold and the exhaust manifolds. Remove the shield from between the lower intake manifold and the exhaust manifolds.



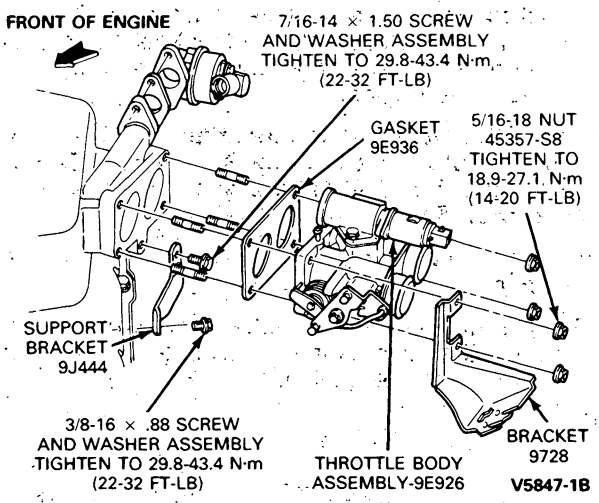
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REMOVAL AND INSTALLATION (Continued)

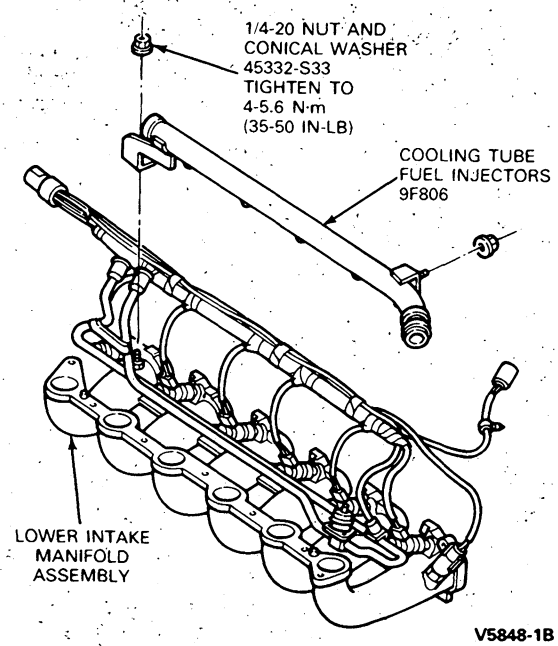
10. Remove the seven studs retaining the upper intake manifold.



11. Remove the screw and washer assembly attaching the upper intake manifold support bracket to the upper intake manifold.



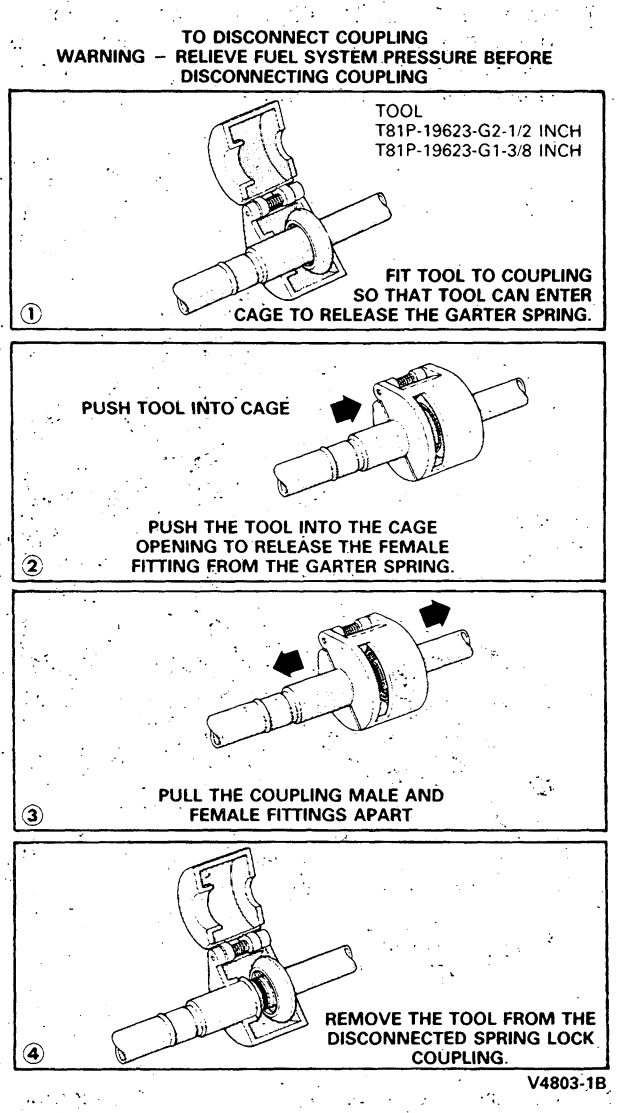
12. Remove the upper intake manifold and throttle body assembly from the lower intake manifold.
13. Move the vacuum harness away from the lower intake manifold.
14. Remove the injector cooling manifold from the lifting eye attachment.



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REMOVAL AND INSTALLATION (Continued)

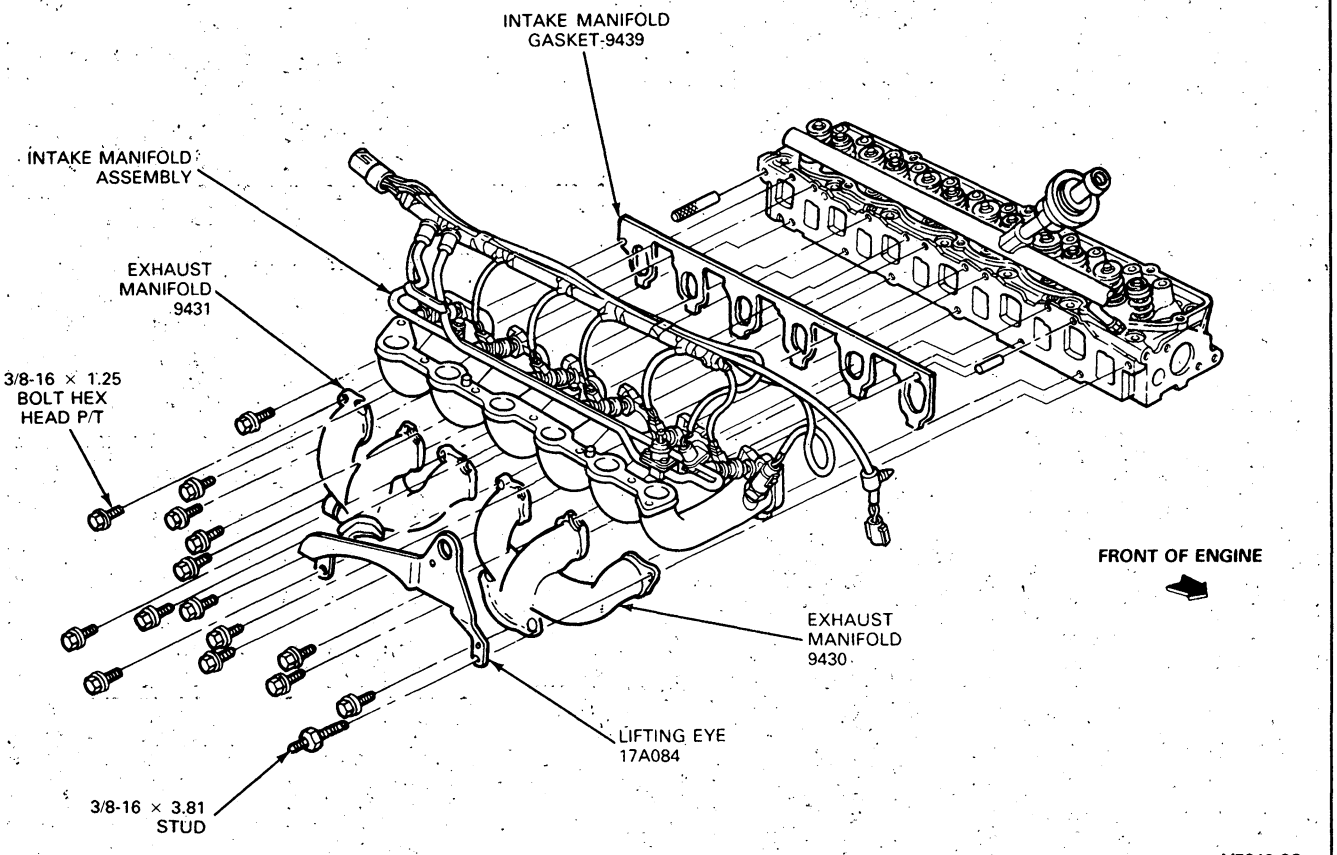
15. Disconnect fuel line retaining clips.
16. Disconnect the fuel supply and fuel return lines using Quick Disconnect Tool D87L-9280-A or D87L-9280-B or equivalents.



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REMOVAL AND INSTALLATION (Continued)

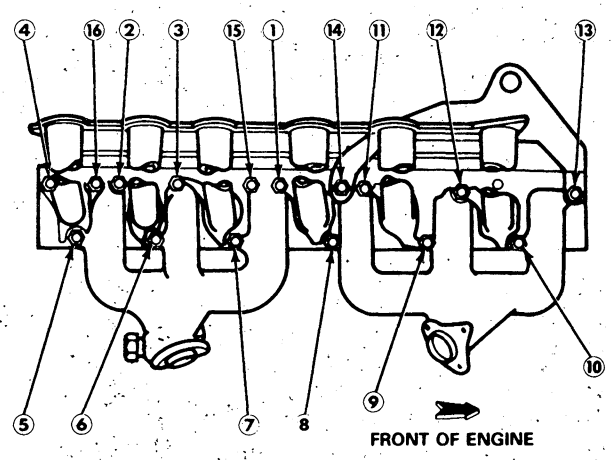
17. Remove 16 bolts attaching both the lower intake manifold and the exhaust manifolds to the cylinder head. Do **not** remove the bolts that attach only the exhaust manifolds.



18. Remove the lower intake manifold assembly from the cylinder head.

Installation

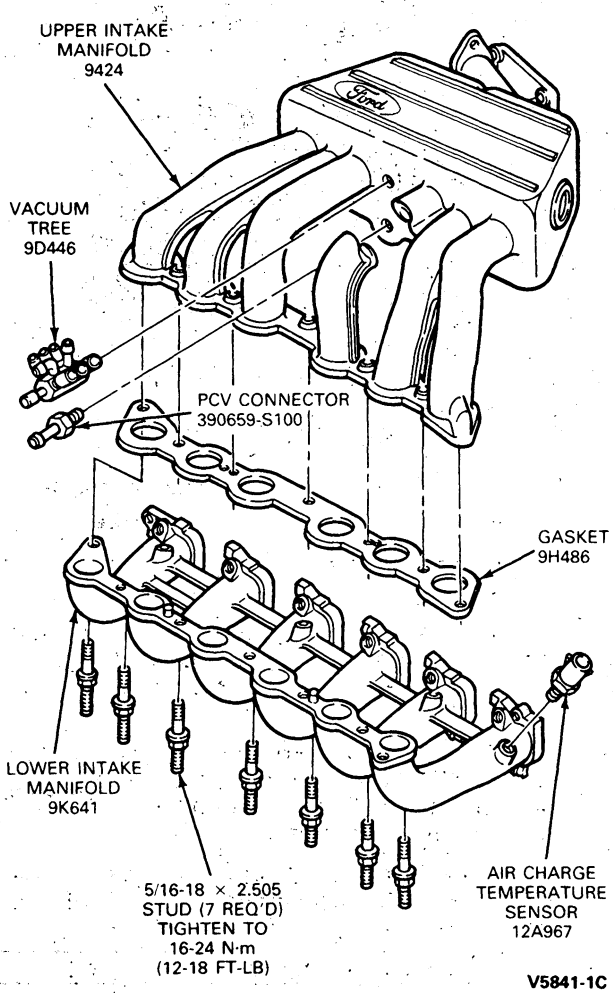
1. Clean and inspect the mounting faces of the lower intake manifold and the cylinder head. Both surfaces must be clean and flat.
2. Clean and oil manifold bolt threads.
3. Position the lower intake manifold and a new gasket to the cylinder head, and install the attachment bolts. Tighten the bolts to 29.8-43.8 N·m (22-32 ft-lb) in the sequence shown.



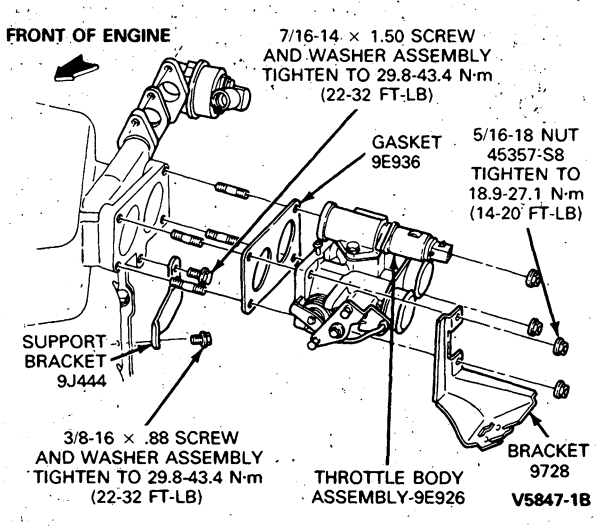
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REMOVAL AND INSTALLATION (Continued)

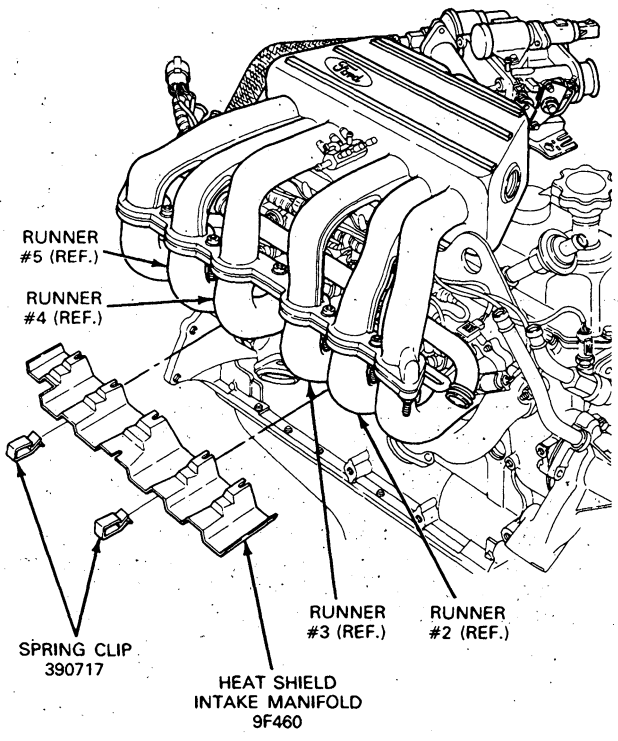
4. Position the vacuum harness, then attach the vacuum connection to the fuel pressure regulator.
5. Install a new upper intake gasket on the lower manifold, using the lower manifold dowels to position the gasket.



6. Position the upper intake manifold onto the lower intake manifold, using the dowels of the lower intake to locate. Install the seven studs attaching the upper intake to the lower intake finger-tight. Then tighten the studs to 16.2- 24.4 N·m (12-18 ft-lb).
7. Position the upper intake manifold support onto the boss of the upper intake, located under the throttle body. Install the retaining screw and tighten to 29.8-43.8 N-m (22-32 ft-lb).



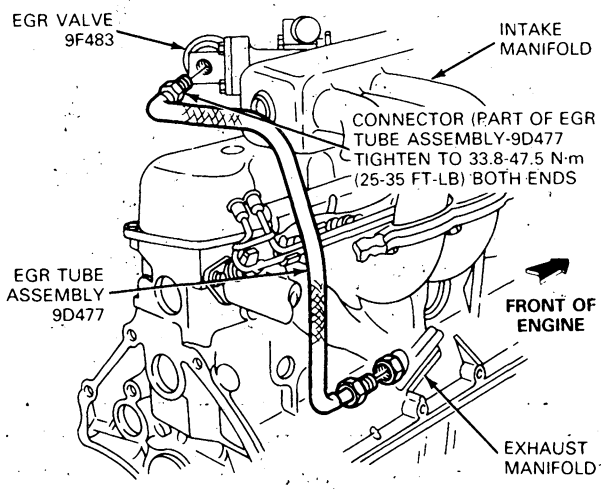
8. Install the injector heat shield between the lower intake manifold and the exhaust manifolds. Secure the shield to the lower intake manifold by installing the two spring clips between the intake runners.



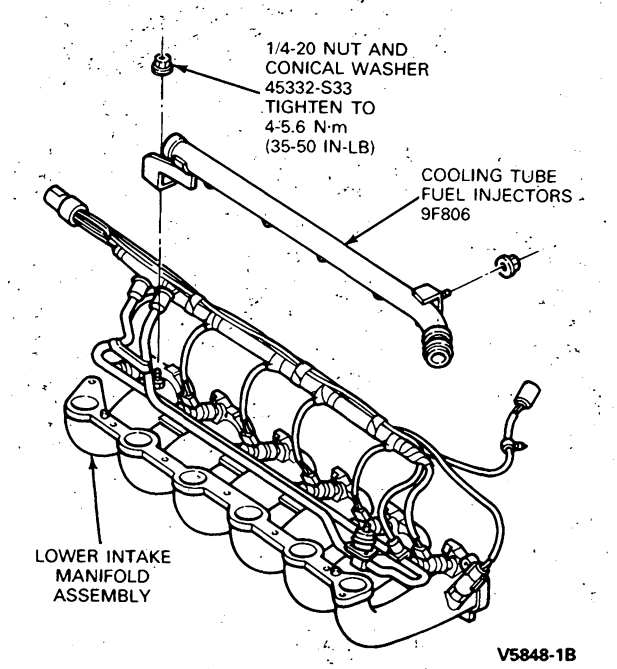
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REMOVAL AND INSTALLATION (Continued)

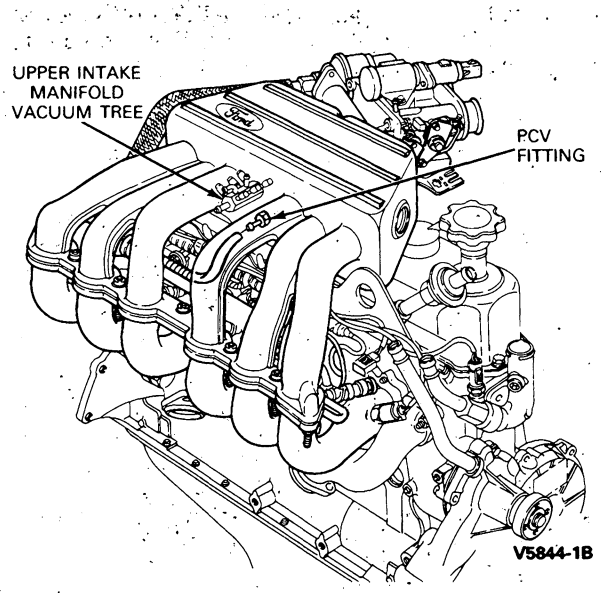
9. Install the EGR tube between the EGR valve and the rear exhaust manifold. The tube is routed between lower intake runners No. 4 and No. 5. Tighten both fittings to 33.8-47.5 N·m (25-35 ft-lb).



10. Install the injector cooling manifold to the lifting eye, and tighten the fastener to 4-5.6 N·m (35-50 in-lb).



11. Connect the PCV hose to the fitting, located on the underside of the upper intake manifold.

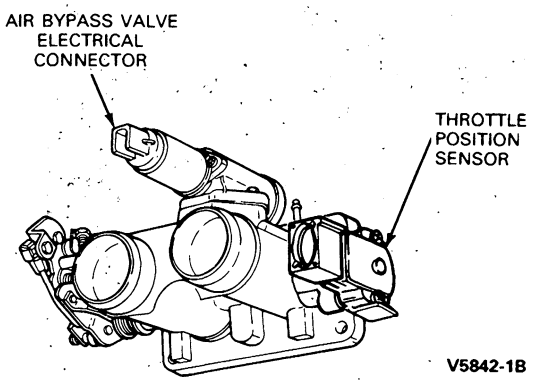


12. Position the Thermactor tube assembly onto the studs of the lower intake manifold. Tighten the attachment nuts to 10.8-16.3 N·m (8-12 ft-lb).
13. For Econoline applications, position the transmission fill tube onto the stud of the lower intake manifold. Tighten the attachment nut to 10.8-16.3 N·m (8-12 ft-lb).
14. Install the accelerator cable and throttle linkage shield onto the accelerator bracket of the throttle body.
15. Connect the air inlet hoses to the throttle body.
16. Connect the following vacuum connections:
    a. Vacuum line to the EGR valve.
    b. Vacuum lines to the Thermactor air bypass valve.
    c. Sealed Housing Evaporative Determination System (S.H.E.D.) evap lines to the throttle body.
    d. Vacuum line to fuel pressure regulator.
    e. Vacuum lines to the upper intake manifold vacuum tree.

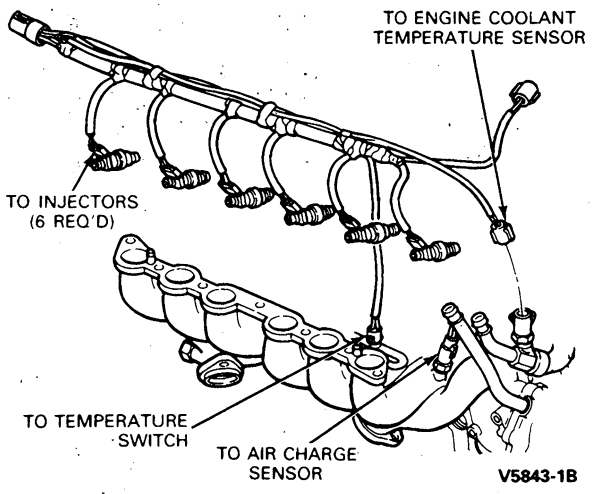
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REMOVAL AND INSTALLATION (Continued)

17. Connect the following electrical connectors at:
    a. Throttle position sensor.
    b. Air bypass valve.



    c. EVP sensor.
    d. Injector wiring harness to main engine harness.
    e. Engine coolant temperature sensor.



18. Connect air intake hose, air bypass hose, and crankcase vent hose.
19. Connect battery ground cable.
20. Install engine coolant following instructions listed on decal located on EEC vacuum reservoir cover. Refer to Group 8.
21. Replace fuel pressure relief cap. Build up fuel pressure as follows: without starting the engine, turn ignition switch back and forth at least six times from ON to OFF position, leaving ignition on for five seconds each time. Check for fuel leaks.
22. Start engine and allow to run at idle until engine temperature stabilizes. Check for cooling system leaks.
23. Use Rotunda Super STAR II 007-00028 or equivalent, with EEC self-test connector to check proper EEC-IV system operation. Refer to the Engine/Emission Diagnosis* manual.
24. Verify correct engine idle.
25. Remove protective covers and close hood.

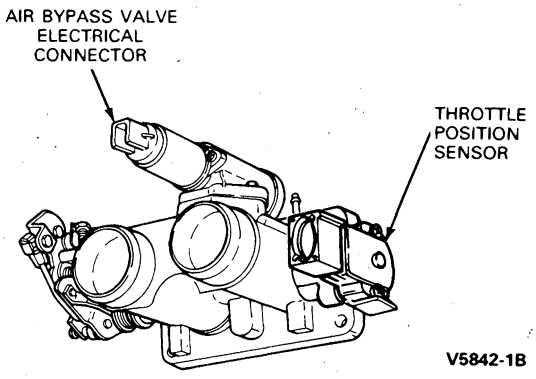
Assembly and Disassembly

The following is a step-by-step sequence of operations for servicing the assemblies of the fuel charging manifold. Some components may be serviced on the vehicle without a complete disassembly of the fuel charging manifold. Pictorial references demonstrate component removal and installation on and/or off the vehicle.

Upper Intake Manifold and Throttle Body Assembly—9424AUP

Removal

1. Disconnect the electrical connectors at:
    a. EVP sensor, located on the EGR valve.
    b. Throttle position sensor.
    c. Air bypass valve.

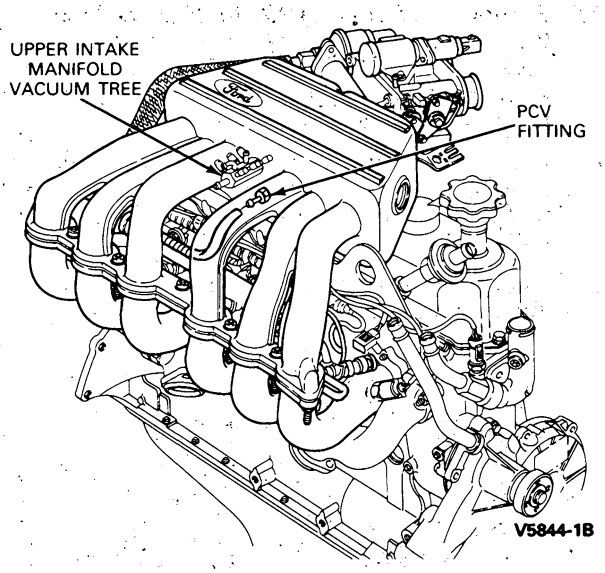


*Can be purchased as a separate item.

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REMOVAL AND INSTALLATION (Continued)

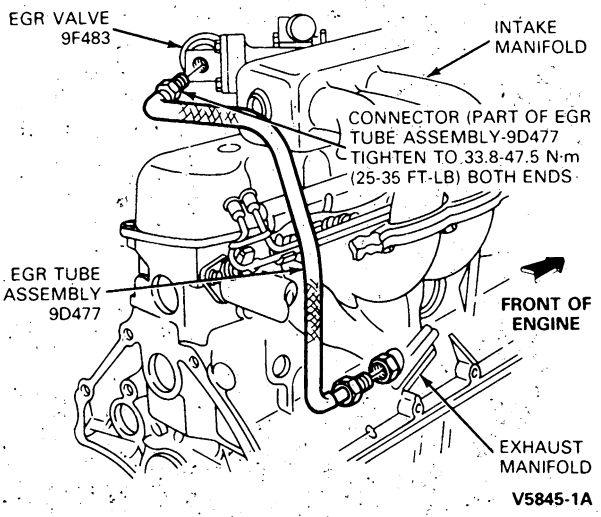
2. Disconnect the following vacuum connections:
   a. Vacuum line at the EGR valve.
   b. Sealed Housing Evaporative Determination System (S.H.E.D.) evap lines to the throttle body.
   c. Vacuum lines to the upper intake manifold vacuum tree. Labeling the hose locations with tape is recommended to aid installation.



3. Disconnect the PCV hose from the fitting, located on the underside of the upper intake manifold.
4. Remove the throttle linkage shield, and disconnect the throttle linkage and speed control cables. Unbolt the accelerator cable from the bracket and position the cable away from the engine.

CAUTION: When disconnecting throttle cable from ball stud, use a screwdriver or similar tool close to the ball stud to pry off. Removing by hand may damage the cable.

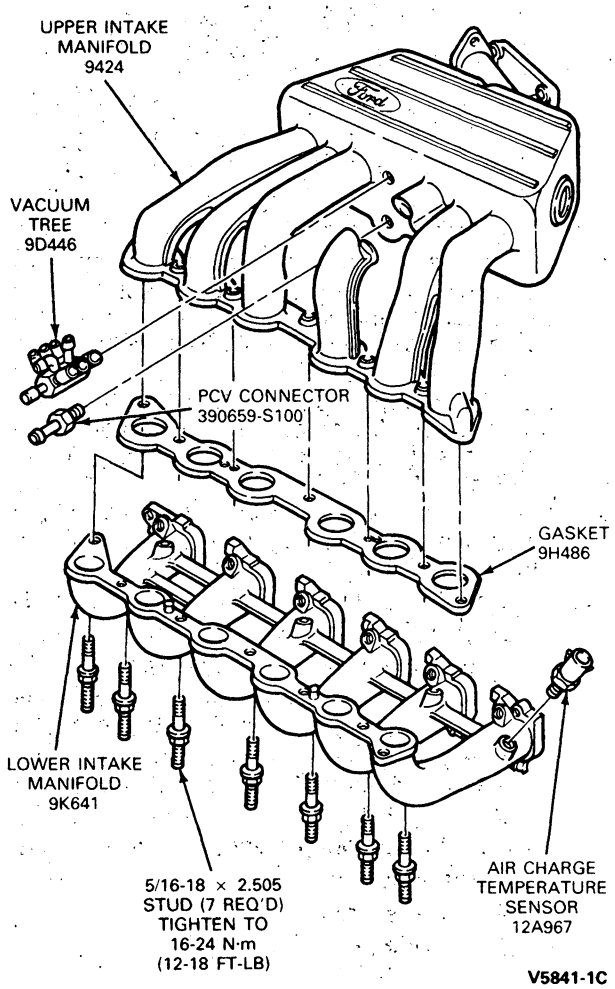
5. Disconnect the air inlet hoses from the throttle body.
6. Disconnect the EGR tube from the EGR valve and the rear exhaust manifold. Remove the tube from the engine.



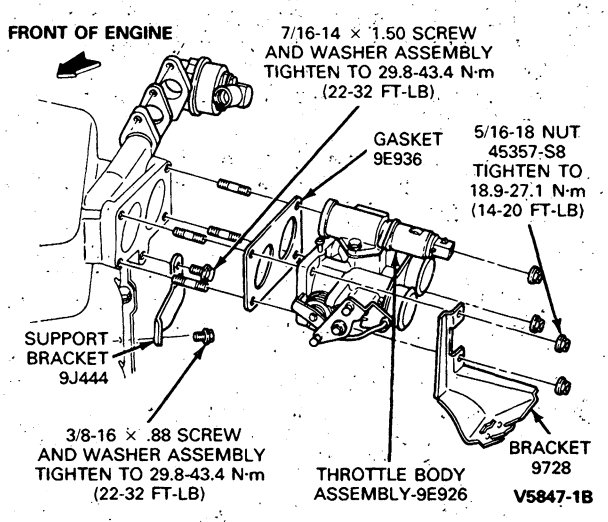
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REMOVAL AND INSTALLATION (Continued)

7. Remove the Thermactor tube assembly from the lower intake manifold by removing the two nuts retaining the tube. Remove the nut attaching the Thermactor bypass valve bracket to the lower intake manifold.
8. For E-series applications only, remove the nut attaching the transmission fill tube. Then remove the tube bracket off the intake manifold stud.
9. Remove the seven studs that retain the upper intake manifold.

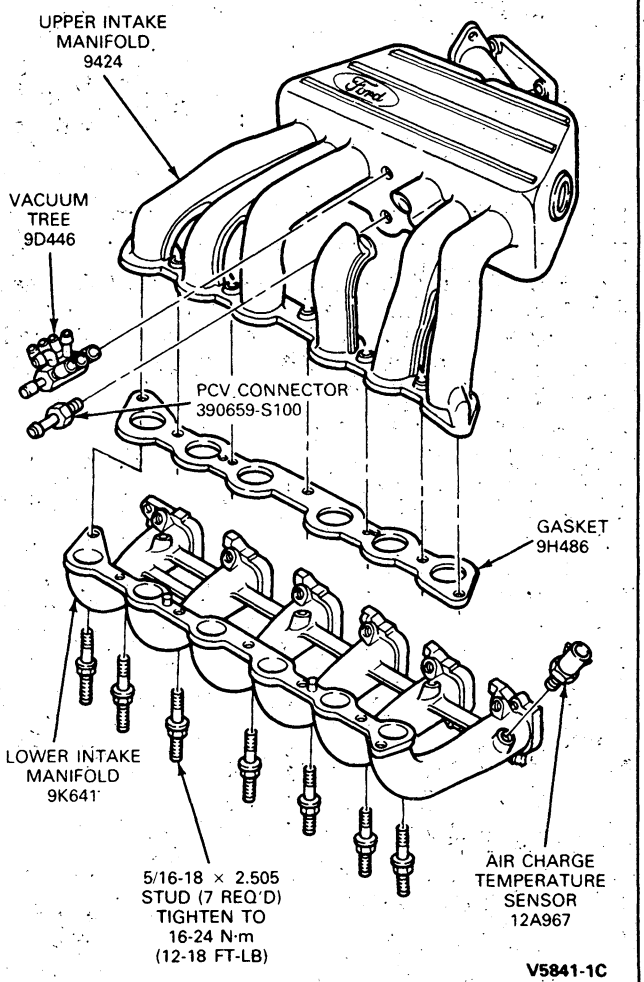


10. Remove the screw and washer assembly attaching the upper intake manifold support bracket to the upper intake manifold.
11. Remove the upper intake manifold and throttle body assembly from the lower intake manifold.



Installation

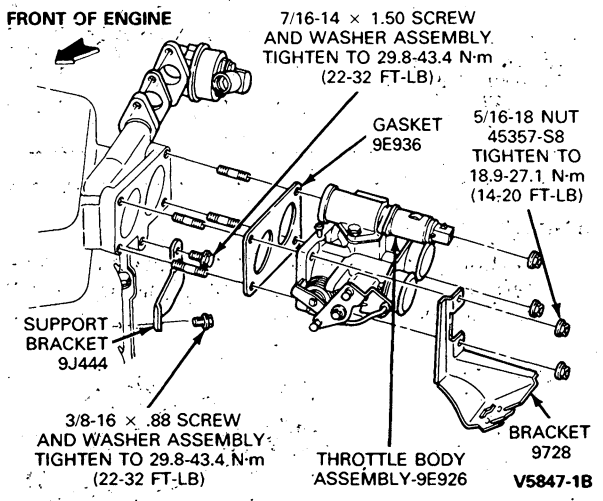
1. Position a new upper intake gasket on the lower manifold, using the lower manifold dowels to position the gasket.



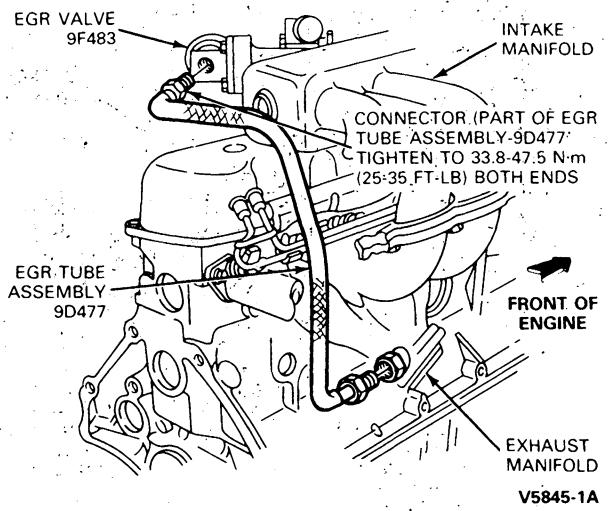
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REMOVAL AND INSTALLATION (Continued)

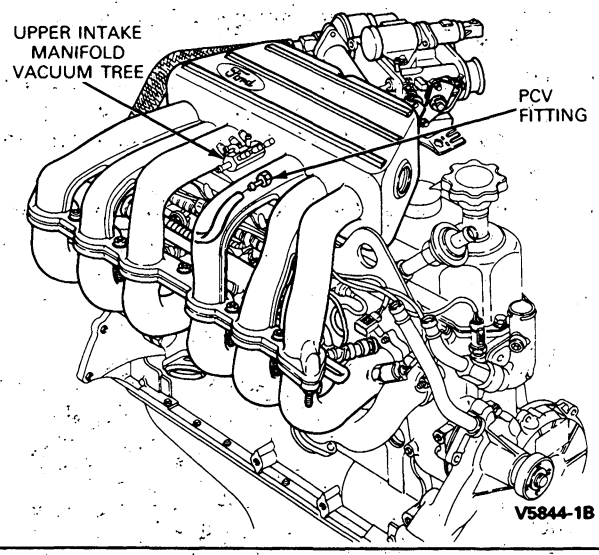
2. Position the upper intake manifold onto the lower intake manifold, using the dowels of the lower intake to locate. Install the seven studs to attach the upper intake to the lower intake finger-tight.
3. Tighten the seven studs, attaching the upper intake to the lower intake manifold, to 16.2-24.4 N·m (12-18 ft-lb).
4. Position the upper intake manifold support onto the boss of the upper intake, located under the throttle body. Install the retaining screw and tighten to 29.8-43.4 N·m (22-32 ft-lb).



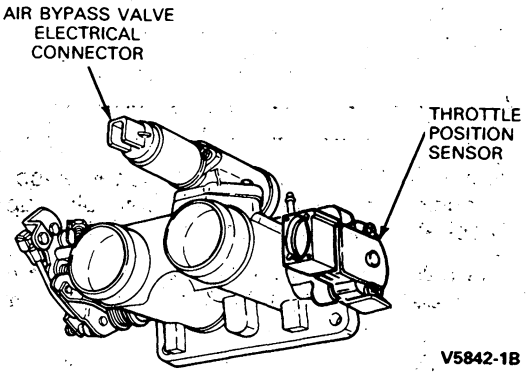
5. Install the EGR tube between the EGR valve and the rear exhaust manifold. The tube is routed between lower intake runners No. 4 and No. 5. Tighten both fittings to 33.8-47.5 N·m (25-35 ft-lb).



6. Connect the PCV hose to the fitting, located on the underside of the upper intake manifold.



7. Position the Thermactor tube assembly onto the studs of the lower intake manifold, and tighten the attachment nuts to 10.8-16.3 N·m (8-12 ft-lb).
8. For Econoline applications, position the transmission fill tube onto the stud of the lower intake manifold. Tighten the attachment nut to 10.8-16.3 N·m (8-12 ft-lb).
9. Install the accelerator cable and throttle linkage shield onto the accelerator bracket of the throttle body.
10. Connect the air inlet hoses to the throttle body.
11. Connect the following vacuum connections:
    a. Vacuum line to the EGR valve.
    b. Sealed Housing Evaporative Determination System (S.H.E.D.) evap lines to the throttle body.
    c. Vacuum lines to the upper intake manifold vacuum tree.
12. Connect the following electrical connectors at:
    a. Throttle position sensor.
    b. Air bypass valve.
    c. EVP sensor.



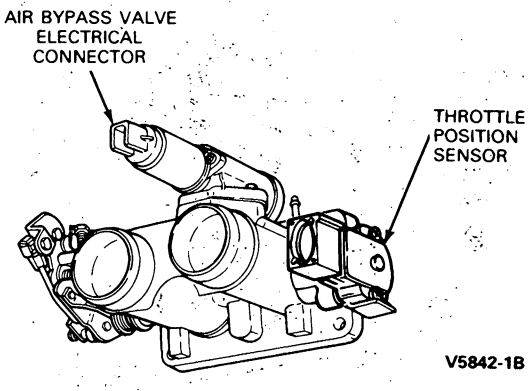
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REMOVAL AND INSTALLATION (Continued)

Air Intake Throttle Body

Removal

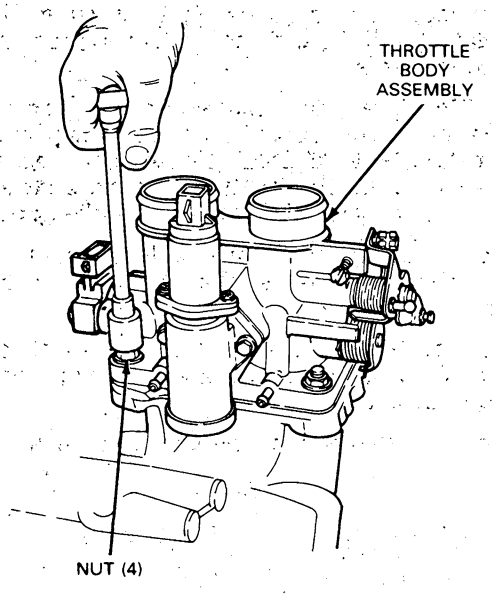
1. Disconnect throttle position sensor and air bypass valve connectors.



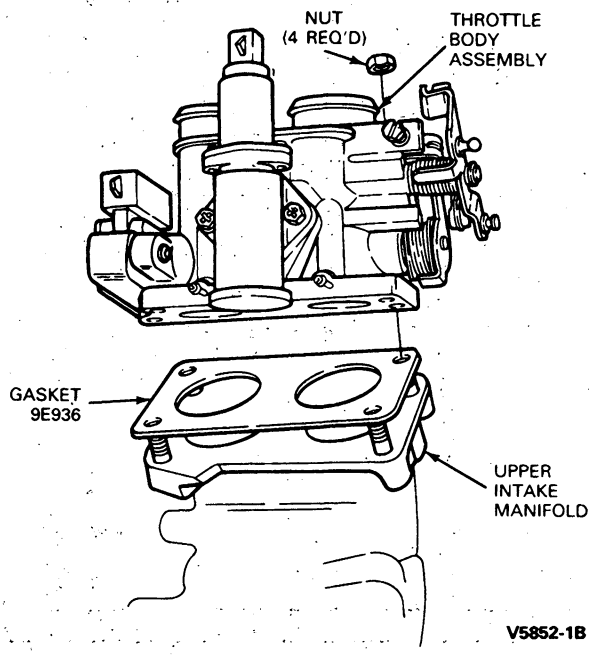
2. Disconnect throttle linkage shield, throttle cable, and speed control cable.

CAUTION: When disconnecting throttle cable from ball stud, use a screwdriver or similar tool close to the ball stud to pry off. Removing by hand may damage the cable.

3. Disconnect the air inlet hoses from the throttle body.
4. Disconnect the SHED EVAP harness from the purge ports of the throttle body.
5. Remove four throttle body nuts.



6. Carefully separate air throttle body and accelerator bracket from upper intake manifold.
7. Remove and discard gasket between throttle body and upper intake manifold.



Installation

1. Ensure that both throttle body and upper intake manifold gasket surfaces are clean.

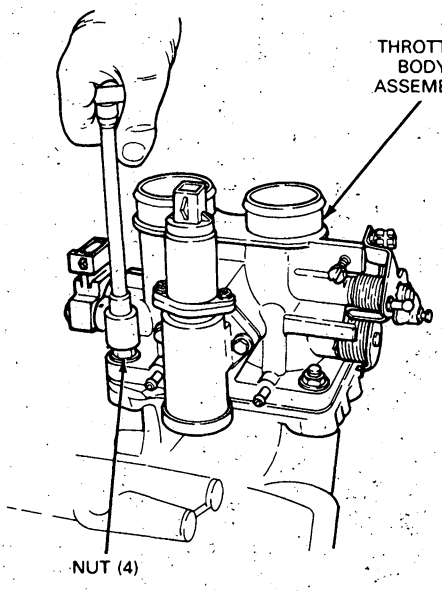
NOTE: If scraping is necessary, be careful not to damage gasket surfaces of throttle body and upper manifold assemblies, or allow material to drop into manifold.

2. Install a new (9E936) throttle body gasket on the four studs of the upper intake manifold.
3. Position the accelerator bracket onto the throttle body.
4. Install throttle body to upper intake manifold.

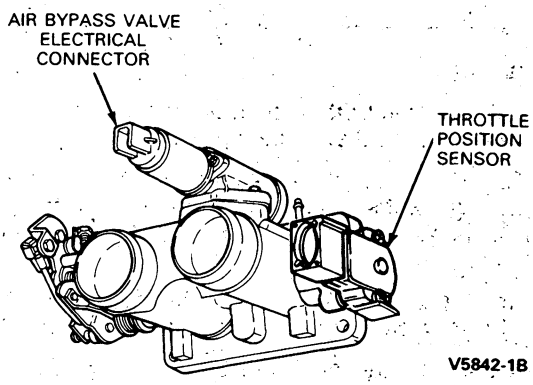
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REMOVAL AND INSTALLATION (Continued)

5. Secure throttle body assembly to upper intake manifold with four retaining nuts. Tighten to 18.9-32.5 N·m (14-20 ft-lb).



6. Connect air bypass valve and throttle position sensor electrical connectors.

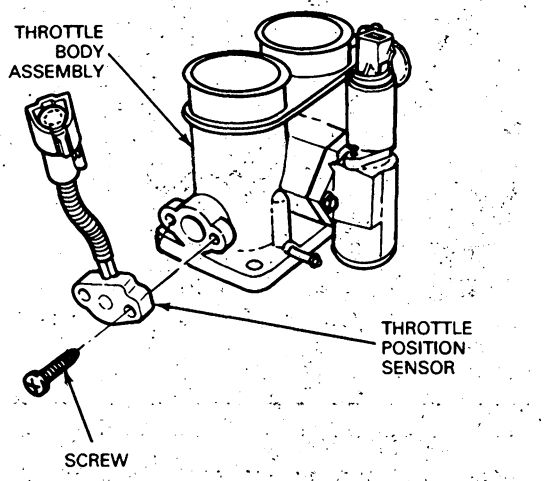


7. Connect the SHED EVAP harness to the purge ports of the throttle body.
8. Connect the throttle linkage and cables to the throttle body and accelerator bracket.
9. Connect the air inlet hoses to the throttle body.

Throttle Position Sensor

Removal

1. Disconnect throttle position sensor from wiring harness.



2. Remove two throttle position sensor retaining screws.
3. Remove throttle position sensor.

Installation

1. Position the throttle position sensor so that the connector points opposite the air valve. Then, rotate throttle position sensor clockwise to align scribe marks.

CAUTION: Slide rotary tanks into position over throttle shaft blade, then rotate throttle position sensor CLOCKWISE ONLY to installed position. Failure to install the throttle position sensor in this manner may result in excessive idle speeds.

2. Secure sensor to throttle body assembly with two retaining screws. Tighten to 2.0-3.0 N·m (17.7-26.5 lb-in).

NOTE: When throttle position sensor is installed on the throttle body, the connector will point toward the throttle body inlet.

3. Connect electrical connector to harness.

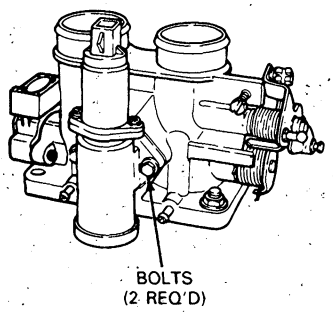
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REMOVAL AND INSTALLATION (Continued)

Air Bypass Valve Assembly

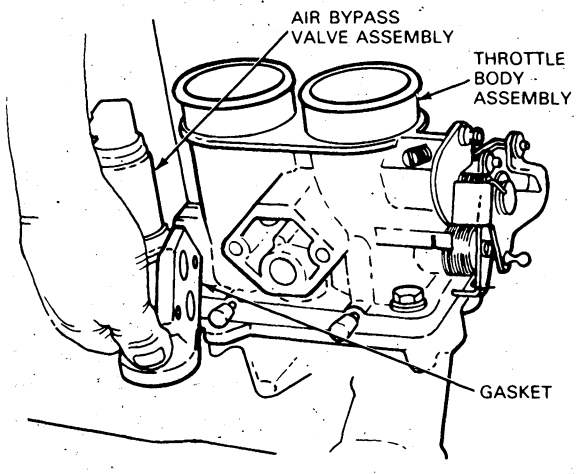
Removal

1. Disconnect the air bypass valve assembly connector from the wiring harness.
2. Remove the two air bypass valve retaining bolts.



V5853-1B

3. Remove the air bypass valve and gasket.



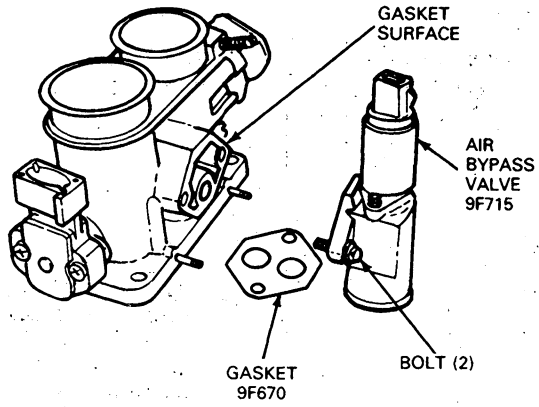
V4800-1B

Installation

1. Ensure that both throttle body and air bypass valve gasket surfaces are clean.

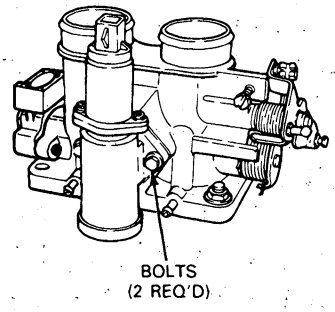
CAUTION: If scraping is necessary, be careful not to damage air bypass valve or throttle body gasket surfaces, or drop material into throttle body.

2. Install gasket and air bypass valve on throttle body surfaces.



V4801-1B

3. Install retaining screws. Tighten to 8-11 N·m (71-102 lb-in).
4. Connect electrical connector for the air bypass valve.



V5853-1B

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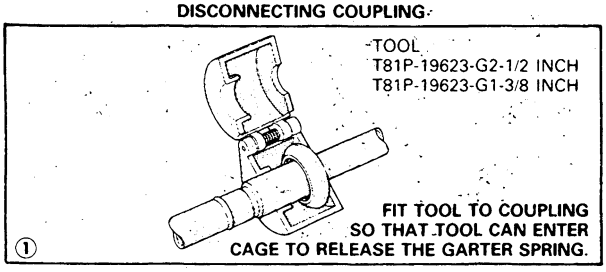
REMOVAL AND INSTALLATION (Continued)

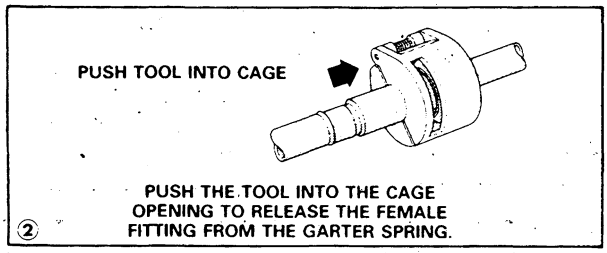
Fuel Supply Manifold Assembly

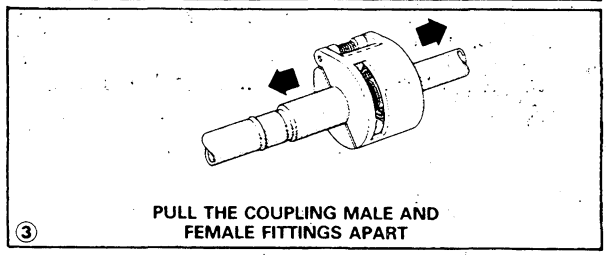
Removal

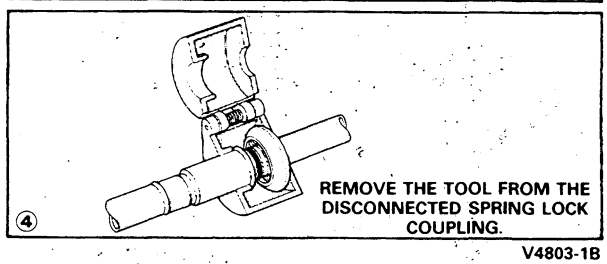
1. Remove the upper intake manifold assembly as outlined in this Section.
2. Disconnect fuel line retaining clips.
3. Disconnect the fuel supply and fuel return lines using Quick Disconnect Tool D87L-9280-A or D87L-9280-B or equivalents.

TO DISCONNECT COUPLING
WARNING – RELIEVE FUEL SYSTEM PRESSURE BEFORE DISCONNECTING COUPLING.



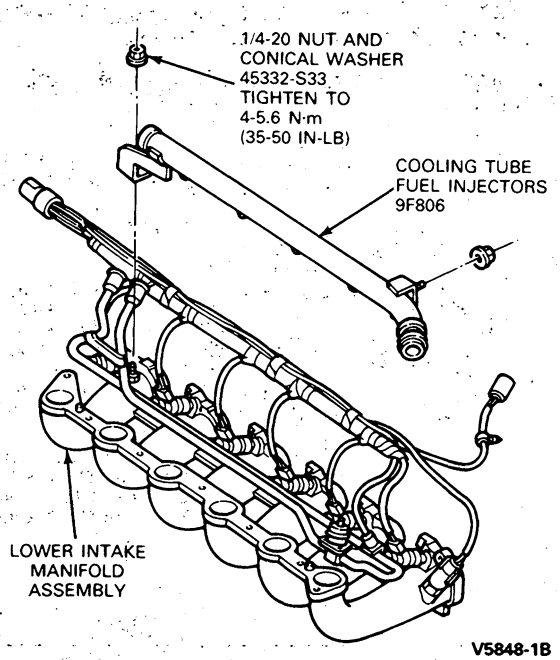






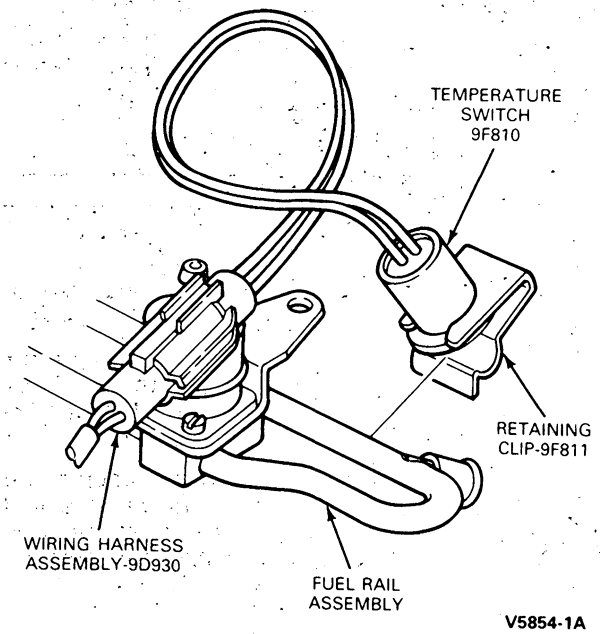
V4803-1B

4. Remove the injector cooling manifold from the lifting eye attachment.



V5848-1B

5. Remove the injector cooling manifold attaching nut from the fuel rail stud. Then remove the injector cooling manifold.
6. Disconnect the electrical connector from the fuel manifold temperature switch.

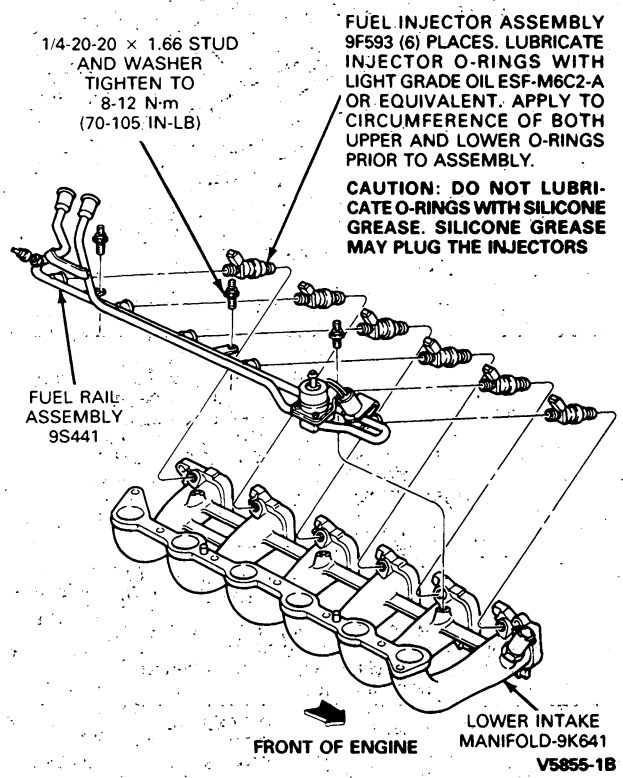


V5854-1A

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REMOVAL AND INSTALLATION (Continued)

7. Disconnect the vacuum line to the fuel pressure regulator.
8. Remove the strap surrounding the fuel manifold, injector electrical harness, and the main vacuum harness.
9. Remove the three fuel supply manifold retaining studs.
10. Carefully disengage the fuel supply manifold from the fuel injectors and remove the manifold.

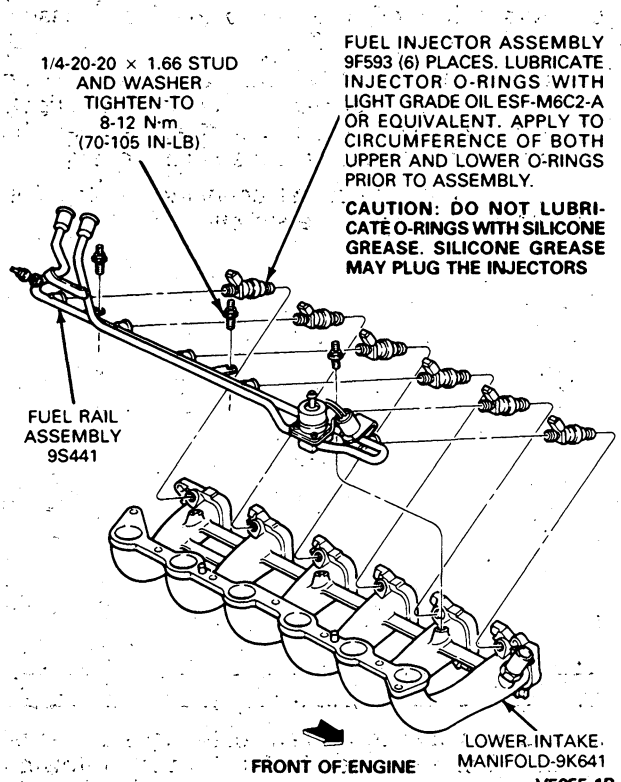


Installation

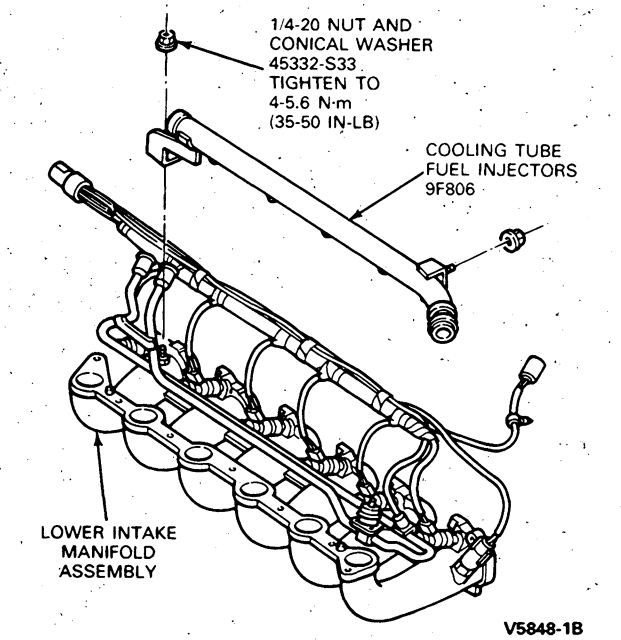
1. Ensure injector caps are clean and free of contamination.

CAUTION: Do not attempt to clean the injector pintle or metering orifice area with brush or tools. Use Rotunda Injector Cleaner/Tester 113-00001 or equivalent.

2. Place the fuel supply manifold over each of the injectors and seat the injectors into the fuel supply manifold. Ensure injectors are well seated in the fuel supply manifold assembly.



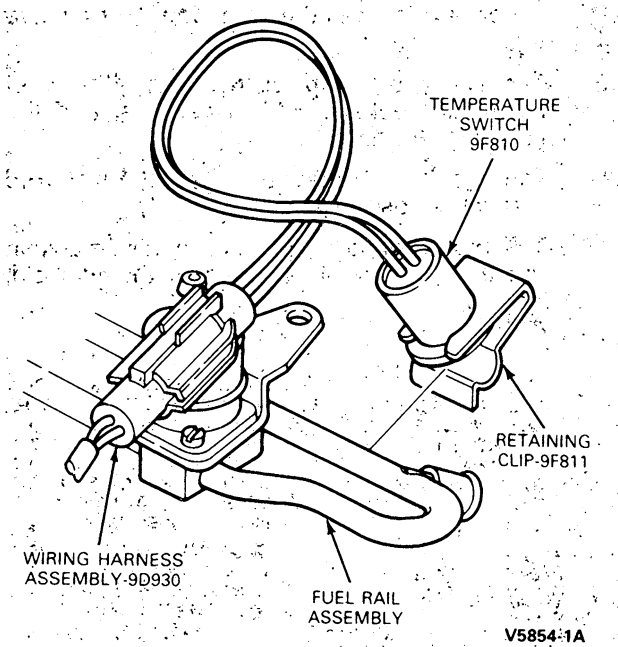
3. Secure the fuel supply manifold assembly using the three retaining studs. Tighten to 20.3-29.8 N·m (15-22 ft-lb).
4. Position and secure the injector cooling manifold. Tighten both nuts to 4-5.6 N·m (35-50 in-lb).



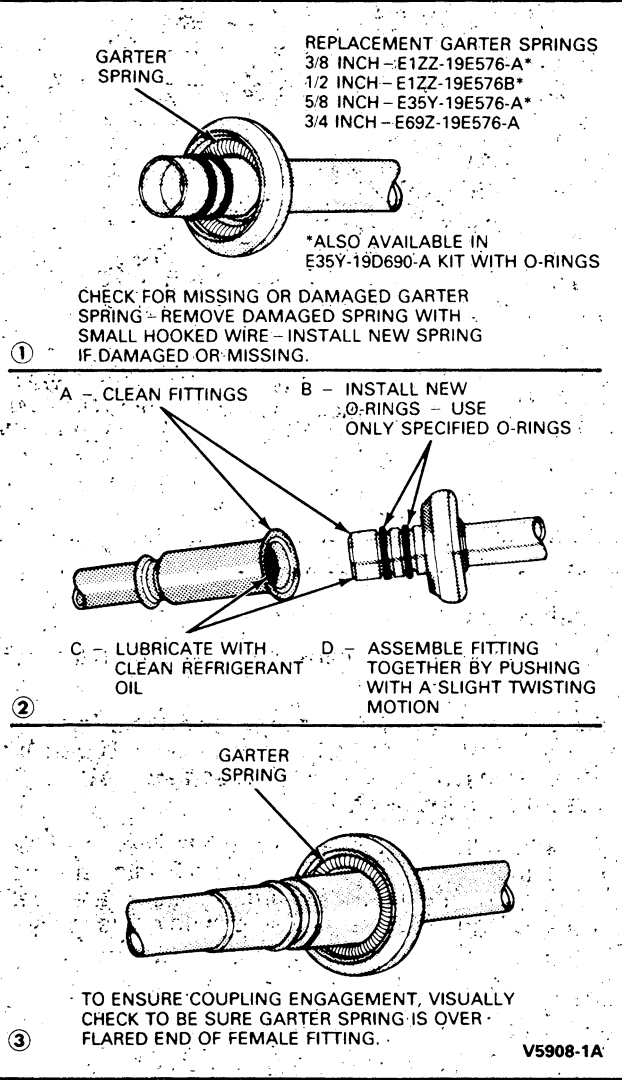
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REMOVAL AND INSTALLATION (Continued)

5. Attach the vacuum line to the fuel pressure regulator.
6. Secure the main vacuum harness and the injector electrical harness to the fuel supply manifold with a strap positioned between the No. 5 and No. 6 intake manifold runners.
7. Connect the electrical connector to the fuel manifold temperature switch.



8. Connect the fuel inlet and outlet lines at the fuel rail connections. Refer to the following illustration.
9. Connect fuel line retaining clips.
10. Install the upper intake manifold as outlined in this Section.



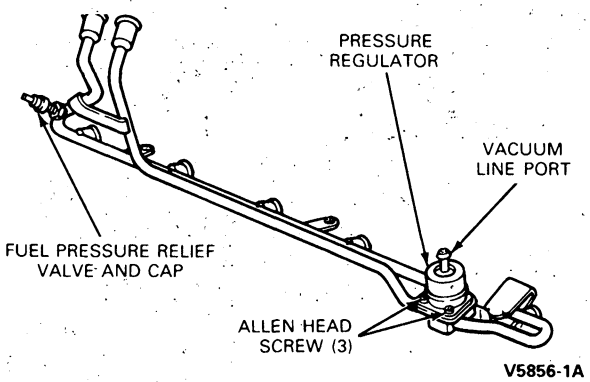
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REMOVAL AND INSTALLATION (Continued)

Fuel Pressure Regulator—9C968

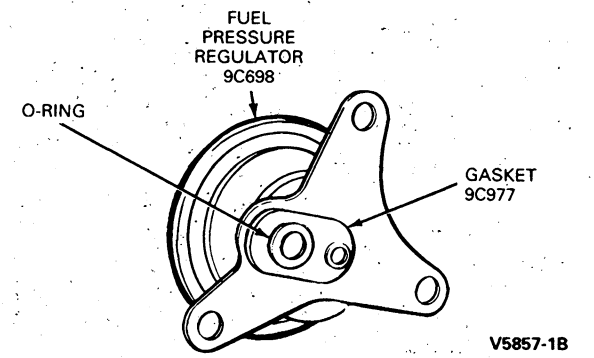
Removal

1. Ensure assembly is depressurized by removing fuel filler cap and releasing pressure from fuel system by opening the pressure relief valve on the fuel line in the upper RH corner of the engine compartment. Use EFI Pressure Gauge T80L-9974-B or equivalent.



2. Remove vacuum line at pressure regulator.
3. Remove three Allen retaining screws from regulator housing.
4. Remove pressure regulator assembly, gasket and O-ring. Discard gasket and inspect O-ring for signs of cracks or deterioration.

CAUTION: If scraping is necessary, be careful not to damage fuel pressure regulator or fuel supply line gasket surfaces.

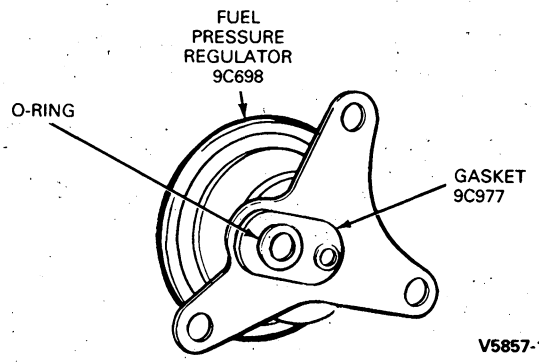


Installation

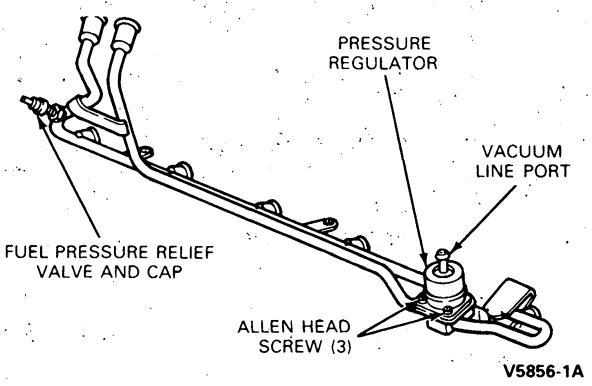
1. Lubricate fuel pressure regulator O-ring with light oil ESF-M6C2-A or equivalent.

CAUTION: Never use silicone grease. It will clog the injectors.

2. Make sure gasket surfaces of fuel pressure regulator and fuel injection manifold are clean.
3. Install O-ring and new gasket on regulator.



4. Install fuel pressure regulator on injector manifold. Tighten three retaining screws to 3.0-4.5 N·m (27-40 in-lb).
5. Install vacuum line at pressure regulator.



Pressure Relief Valve—9H321

Removal

1. If the fuel charging assembly is mounted to the engine, remove fuel filler cap and release pressure from the system by opening the pressure relief valve on the fuel line in the upper RH corner of the engine compartment. Use EFI Fuel Pressure Gauge T80L-9974-B or equivalent.

NOTE: The cap on the relief valve must be removed.

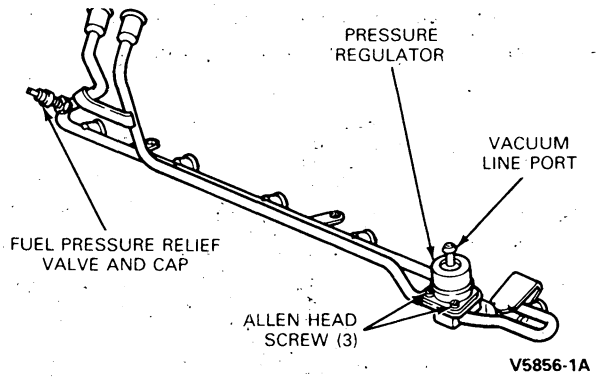
2. Using an open end wrench, remove pressure relief valve from fuel line.

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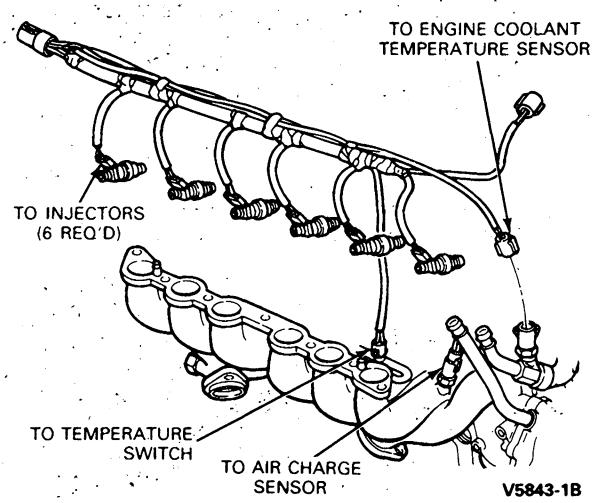
REMOVAL AND INSTALLATION (Continued)

Installation

1. Install pressure relief valve and cap. Tighten valve to 5.5-9.5 N·m (48-84 in-lb). Tighten cap to 0.5-0.7 N·m (4-6 in-lb).



6. Use Rotunda Super STAR II 007-00028 or equivalent, with EEC self-test connector and procedure to check for sensor function. Refer to the Engine/Emission Diagnosis* manual.



Fuel Injection Wiring Harness

Removal

NOTE: Ensure ignition is in OFF position and fuel system is depressurized.

1. Disconnect electrical connectors from all six fuel injectors.
2. Disconnect connector from main wiring harness.
3. Disconnect electrical connectors at fuel temperature switch, air charge temperature switch, and coolant temperature switch.
4. Remove wiring assembly.

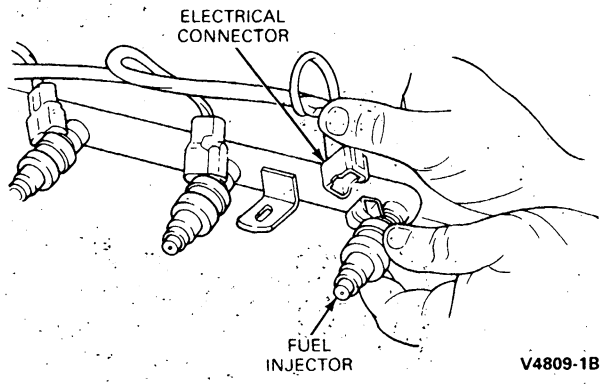
Installation

1. Position wiring harness alongside the fuel injectors.
2. Snap electrical connectors into position on all six injectors.
3. Connect main harness connector.
4. Connect electrical connectors at fuel temperature switch, air charge temperature switch, and coolant temperature switch.
5. Verify that all electrical connectors are firmly seated.

Fuel Injector

Removal

1. Perform Steps 1-5 under Fuel Charging Assembly— Pre-Service Procedures.
2. Remove upper intake manifold as outlined in this Section.
3. Carefully remove electrical harness connectors from individual injectors as required.
4. Remove fuel supply manifold as outlined in this Section.

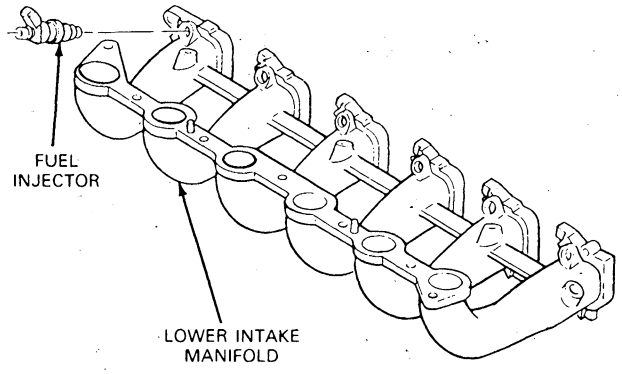


*Can be purchased as a separate item.

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REMOVAL AND INSTALLATION (Continued)

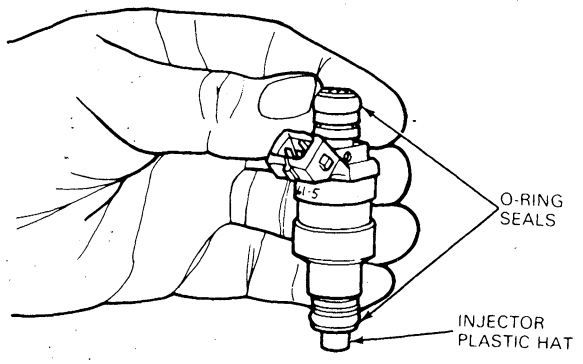
5. Grasping injector body, pull up while gently rocking injector from side-to-side.



V5858-1A

6. Inspect injector O-rings (two per injector) for signs of deterioration. Replace as required.

CAUTION: Do not attempt to clean the injector pintle or metering orifice with tools or brushes. Use Rotunda Injector Cleaner/Tester 113-00001 or equivalent.



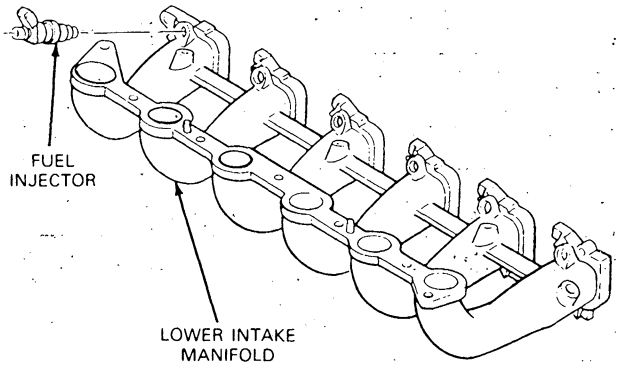
V5040-1A

Installation

1. Lubricate new O-rings with light grade oil ESF-M6C2-A or equivalent and install two on each injector.

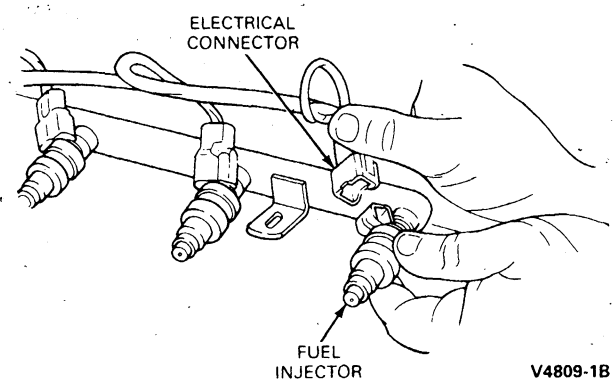
CAUTION: Never use silicone grease. It will clog the injectors.

2. Install injector(s) using a light, twisting, pushing motion.
3. Install fuel supply manifold as outlined in this Section.



V5858-1A

4. Install electrical harness connectors to injectors.
5. Install upper intake manifold as outlined in this Section. Perform Steps 1-5 of Fuel Charging Assembly—Pre-Service Procedures.



V4809-1B

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SPECIFICATIONS

TORQUE SPECIFICATIONS

Description	N-m	Ft-Lb
Lower Intake Manifold to Head	30-43	22-32
EGR Tube	33.8-47.5	25-35
EGR Valve to Upper Intake Manifold	17-25	13-19
Cooling Manifold	4-5.6	35-50 in-lb
Upper Intake Manifold to Lower Intake Manifold Bolts	16.2-24.4	12-18
Throttle Body to Upper Intake Manifold	16-24	12-18
Air Bypass Valve to Throttle Body	8-11	71-102 in-lb
Throttle Position Sensor to Throttle Body	2.0-3.0	18-26.5 in-lb
Fuel Pressure Regulator to Injector Manifold	3-4.5	27-40 in-lb
Fuel Injector Manifold to Fuel Charging Assembly	16-20	12-15
Coil Bracket to Manifold Stud	5.9-7.4	52-65 in-lb
Throttle Cable Bracket to Manifold	11-13	8-10
Air Door Bracket to A/C Cleaner	7.9-11.2	70-100 in-lb

CV4866-1E

SPECIAL SERVICE TOOLS

Tool Number	Description
D87L-9280-B	Spring Lock Coupling Remover 1/2 Inch
D87L-9280-A	Spring Lock Coupling Remover 3/8 Inch
T80L-9974-B	EFI Fuel Pressure Test Gauge

CV4867-1C

ROTUNDA EQUIPMENT

Number	Description
007-00028	Super S.T.A.R. II
113-00001	Injector Cleaner Tester

CV5889-1B

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SECTION 24-32 Electronic Fuel Injection—7.5L (460 CID) V-8 Engine

SUBJECT	PAGE
DESCRIPTION AND OPERATION	
Components	24-32-2
REMOVAL AND INSTALLATION	
Air Intake Throttle Body	24-32-7
Fuel Charging Assembly (Throttle Body, Upper and Lower Manifolds)	24-32-5
Fuel Injector	24-32-12
Fuel Pressure Regulator	24-32-11
REMOVAL AND INSTALLATION (Cont'd.)	
Fuel Supply Manifold Assembly	24-32-10
Throttle Air Bypass Valve Assembly	24-32-9
Throttle Position Sensor	24-32-9
Upper Intake Manifold and Throttle Body	24-32-6
SPECIFICATIONS	24-32-14
VEHICLE APPLICATION	24-32-1

VEHICLE APPLICATION

7.5L EFI V-8 Engine over 8500 GVW.

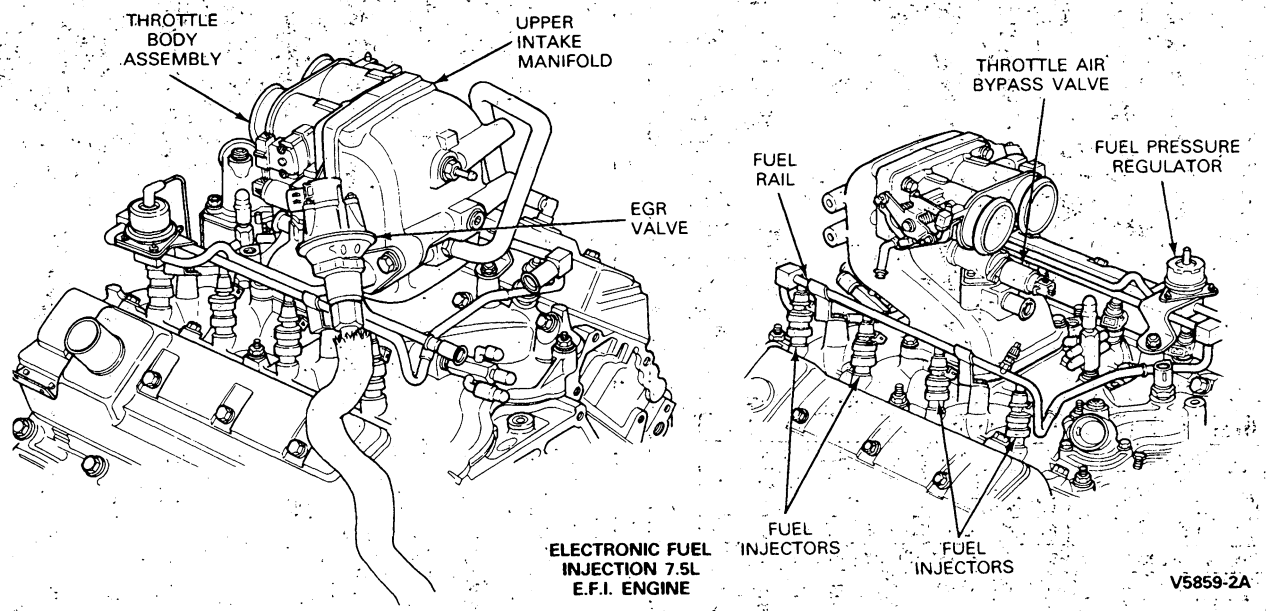
DESCRIPTION AND OPERATION

The electronic fuel injection system (EFI) is classified as a multi-point, pulse time, speed density, fuel injection system. Fuel is metered into the intake air stream in accordance with engine demand through eight injectors mounted on a tuned intake manifold.

An on-board vehicle electronic engine control (EEC-IV) computer accepts inputs from various engine sensors to compute the required fuel flow rate necessary to maintain a prescribed air/fuel ratio throughout the entire engine operational range. The computer then outputs a command to the fuel injectors to meter the appropriate quantity of fuel.

The EEC-IV engine control system also determines and compensates for the age of the vehicle and its uniqueness. The system will automatically sense and compensate for changes in altitude (i.e. from sea level to mountains) and also permits push-starting the vehicle should it become necessary (manual transmission only).

The fuel delivery subsystem consists of a low pressure in-tank mounted fuel pump, a fuel filter/reservoir and a high pressure, chassis mounted electric fuel pump, delivering fuel from the fuel tank through a chassis-mounted 20 micron fuel filter to a fuel charging manifold assembly.



ELECTRONIC FUEL INJECTION 7.5L E.F.I. ENGINE

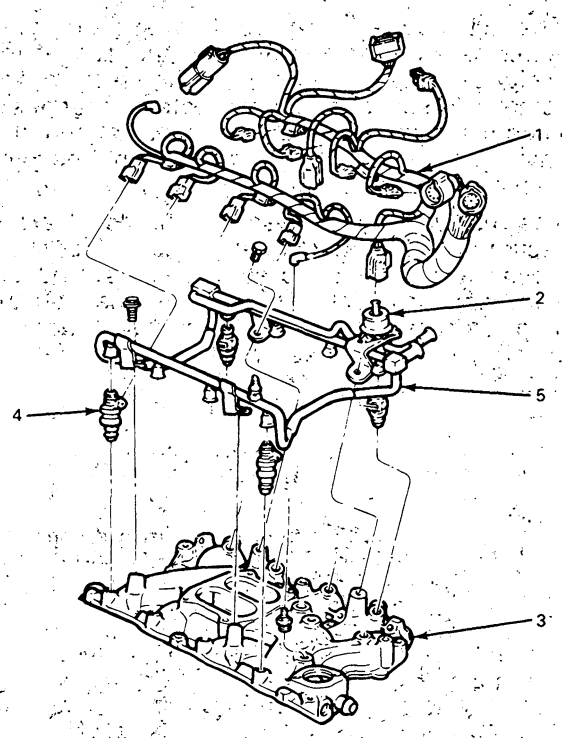
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DESCRIPTION AND OPERATION (Continued)

The fuel charging manifold assembly incorporates electrically actuated fuel injectors directly above each of the engine's eight intake ports. The injectors, when energized, spray a metered quantity of fuel into the intake air stream.

A constant fuel pressure drop is maintained across the injector nozzles by a pressure regulator. The regulator is connected in series with the fuel injectors and is positioned downstream from them. Excess fuel supplied by the pump, but not required by the engine, passes through the regulator reservoir input and returns to the fuel tank through a fuel return line.

One group of four injectors is energized simultaneously, once every crankshaft revolution followed by the second group of injectors in the next crankshaft revolution. The period of time that the injectors are energized (injector "on time" or pulse width) is controlled by the vehicles' electronic engine controls (EEC) computer. The EEC computer receives input from various engine sensors and uses this information to compute the prescribed air/fuel ratio for the given engine operation. The computer determines the needed injector pulse width and outputs a command to the injector to meter the exact quantity of fuel.



7.5L EFI FUEL CHARGING MANIFOLD ASSEMBLY — 9H487

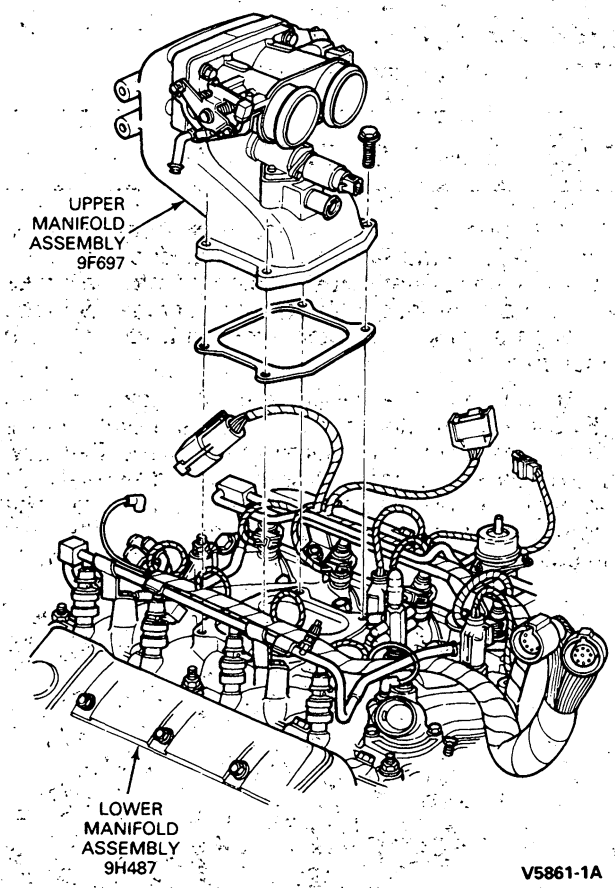
ITEM	PART NO.	PART NAME
1	9D930	WIRING HARNESS — FUEL CHARGING
2	9C968	REGULATOR ASSEMBLY — FUEL PRESSURE
3	9J447	MANIFOLD — INTAKE LOWER
4	9F593	INJECTOR ASSEMBLY — FUEL
5	9F792	MANIFOLD ASSEMBLY — FUEL SUPPLY

V5860-1A

Components

Air Intake Manifold

The air intake manifold is a two-piece (upper and lower intake manifold) aluminum casting. Runner lengths are tuned to optimize engine torque and power output. The manifold provides mounting flanges for the air throttle body assembly, fuel supply manifold and accelerator control bracketry, throttle air bypass valve, and the EGR valve. Vacuum taps are provided to support various engine accessories. Pockets for the fuel injectors are machined to prevent both air and fuel leakage. The pockets in which the injectors are mounted, are placed to direct the injector fuel spray immediately in front of each engine intake valve.



V5861-1A

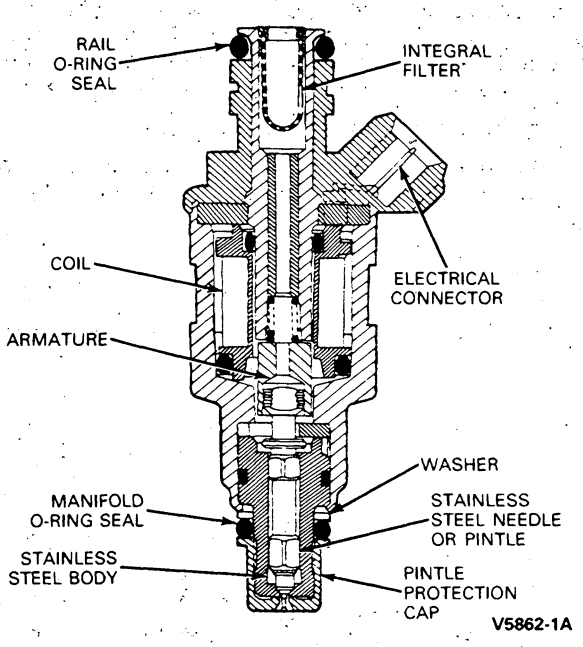
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DESCRIPTION AND OPERATION (Continued)

Fuel Injectors

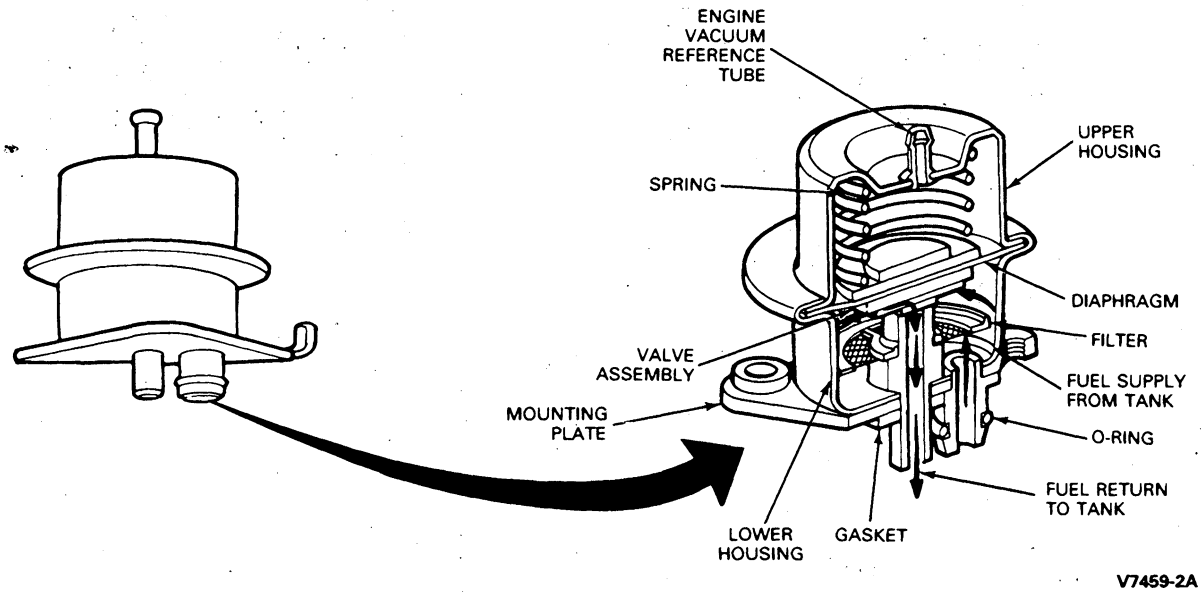
One group of four injectors are energized once every crankshaft revolution. The period of time that the injectors are energized (injector "on time" or the pulse width) is controlled by the vehicles' electronic engine control (EEC) computer. Air charge temperature entering the engine is measured by an air charge temperature sensor located in the lower intake manifold. This information and input from various other engine sensors are used to compute the required fuel flow rate necessary to maintain a prescribed air/fuel ratio for the given engine operation. The computer determines the needed injector pulse width and outputs a command to the injector to meter the exact quantity of fuel.

The fuel injector nozzles are electro-mechanical devices which both meter and atomize fuel delivered to the engine. The EFI injectors are mounted in the lower intake manifold and are positioned so that their tips direct fuel just ahead of the engine intake valves. The valve body consists of a solenoid actuated pintle and needle valve assembly that sits on a fixed size orifice. The fuel pressure, maintained by a regulator is also a constant. Therefore, fuel flow to the engine is regulated by how long the solenoid is energized. An electrical signal from the electronic engine control unit activates the solenoid causing the pintle to move inward off the seat, allowing fuel to flow through the orifice. Atomization of the fuel is obtained by contouring the pintle at the point where the fuel passes through the metering orifice.



Fuel Pressure Regulator

The fuel pressure regulator is attached to the fuel supply manifold assembly downstream of the fuel injectors. It regulates the fuel pressure supplied to the injectors. The regulator is a diaphragm operated relief valve in which one side of the diaphragm senses fuel pressure and the other side is subjected to intake manifold vacuum. The nominal fuel pressure is established by a spring preload applied to the diaphragm. Balancing one side of the diaphragm with manifold pressure maintains a constant fuel pressure drop across the injectors. Fuel in excess of that used by the engine is bypassed through the regulator and returns to the fuel tank.



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DESCRIPTION AND OPERATION (Continued)

Air Throttle Body Assembly

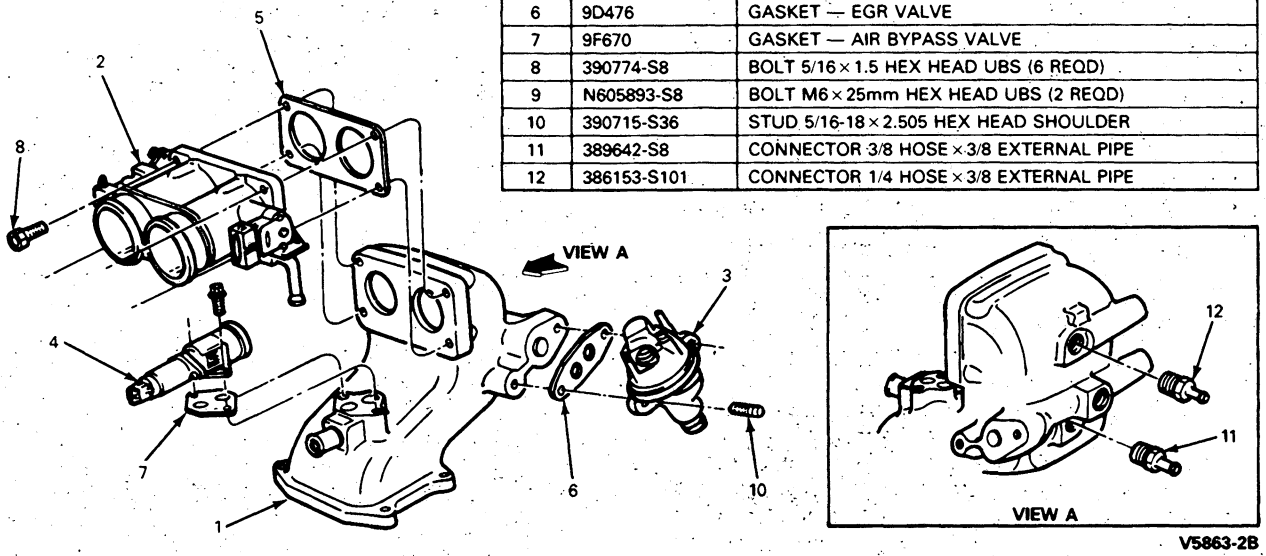
The throttle body assembly controls airflow to the engine through a double butterfly-type valve. The throttle position is controlled by multiple-link, progressive opening, throttle linkage. The body is a single piece die casting made of aluminum. Engine coolant is diverted through the throttle body mounting pad to improve cold weather operation.

Throttle Air Bypass Valve Assembly

The upper intake manifold has a mounting pad on which the throttle air bypass valve assembly is located. The intake manifold has an air bypass channel downstream of the throttle body with external filtered air supplied from the air cleaner. The valve assembly is an electro-mechanical device controlled by the EEC computer. It uses a linear actuator which positions a variable area metering valve. This controls the engine airflow for both cold and warm engine idle.

AIR INTAKE CHARGE THROTTLE BODY AND UPPER MANIFOLD ASSEMBLY

ITEM	PART NO.	PART NAME
1	9424	MANIFOLD ASSEMBLY — INTAKE
2	9E926	BODY ASSEMBLY — AIR INTAKE CHARGE THROTTLE
3	9F483	VALVE ASSEMBLY — EGR VACUUM EXTERNAL
4	9F715	VALVE ASSEMBLY — THROTTLE AIR BYPASS
5	9E936	GASKET — AIR CHARGE CONTROL INTAKE MANIFOLD
6	9D476	GASKET — EGR VALVE
7	9F670	GASKET — AIR BYPASS VALVE
8	390774-S8	BOLT 5/16×1.5 HEX HEAD UBS (6 REQD)
9	N605893-S8	BOLT M6×25mm HEX HEAD UBS (2 REQD)
10	390715-S36	STUD 5/16-18×2.505 HEX HEAD SHOULDER
11	389642-S8	CONNECTOR 3/8 HOSE×3/8 EXTERNAL PIPE
12	386153-S101	CONNECTOR 1/4 HOSE×3/8 EXTERNAL PIPE

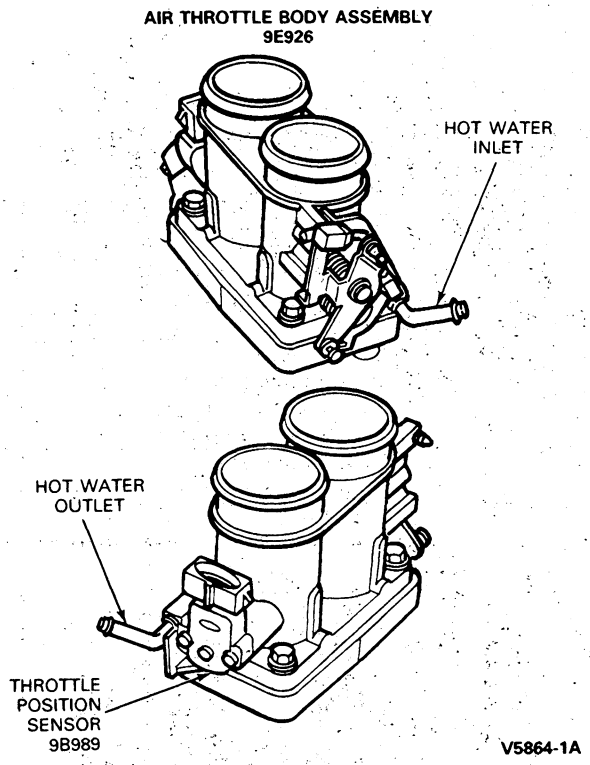


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DESCRIPTION AND OPERATION (Continued)

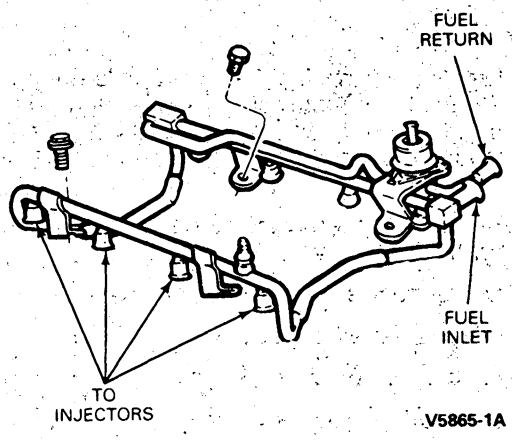
Other features of the air throttle body assembly include:

1. A preset stop to locate the WOT position.
2. A throttle body mounted throttle position sensor.



Fuel Supply Manifold Assembly

The fuel supply manifold assembly is the component that delivers high pressure fuel from the vehicle fuel supply line to the eight fuel injectors. The assembly consists of two banks of tubular fuel rails connected by two permanent crossover connections, eight injector connectors, a mounting flange to the fuel pressure regulator and mounting attachments which locate the fuel manifold assembly and provide fuel injector retention. The fuel inlet and outlet connections have push connect fittings. The unit is serviced as an assembly only.



REMOVAL AND INSTALLATION

Fuel Charging Assembly (Throttle Body, Upper and Lower Manifolds)

Pre-Service Procedures

The fuel charging assembly consists of the air throttle body, and the upper and lower intake manifolds. Prior to service or removal of the fuel charging assembly, the following steps must be taken:

1. Open hood and install protective covers.
2. Disconnect battery ground cable and secure it out of the way.
3. Remove fuel cap to relieve tank pressure.
4. Release pressure from fuel system. A valve at the fuel rail is provided for this. Refer to Section 24-50, Fuel Tanks and Lines for Fuel System Pressure Relief procedures.

Post-Service Procedures

After the service is complete and the fuel charging assembly is installed to engine, the following steps must be taken:

1. Install fuel cap at tank.
2. Connect battery ground cable.
3. Add coolant, if it was removed.
4. Turn ignition switch on/off several times without starting engine to check for fuel leaks.

NOTE: Check all connections at fuel rails, push connect fittings, etc.

CAUTION: The fuel system is normally pressurized to 276 kPa (40 psi).

5. Start engine and warm to operating temperature. Check for coolant leak if coolant was removed.
6. Perform EEC-IV Self Test to check systems function. Refer to Engine/Emissions Diagnosis manual.*

*Can be purchased as a separate item.

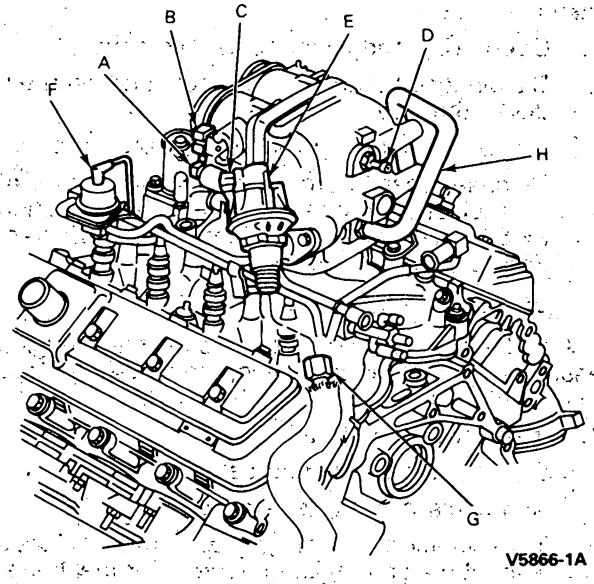
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REMOVAL AND INSTALLATION (Continued)

Upper Intake Manifold and Throttle Body

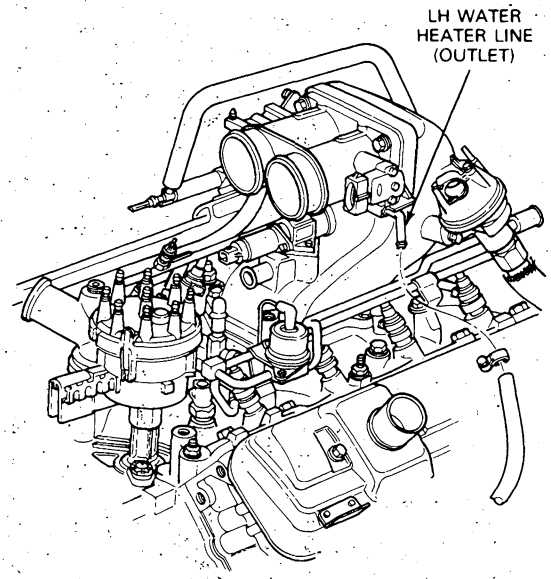
Removal

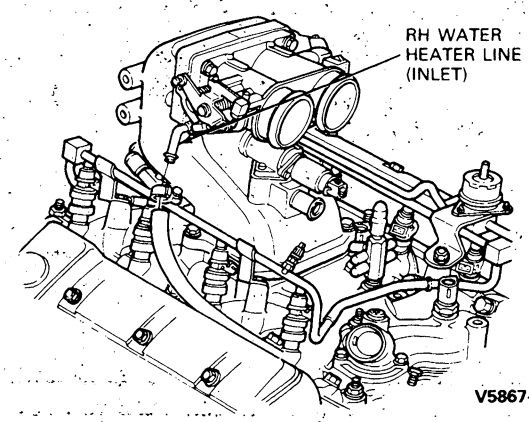
1. Disconnect throttle linkage at throttle ball and automatic transmission linkage from throttle body. Remove two bolts securing bracket to intake and position bracket with cables out of the way.
2. Remove two canister purge lines from fittings on throttle body.
3. Disconnect electrical connectors at:
   a. throttle air bypass valve
   b. throttle position sensor
   c. EGR position sensor.
4. Disconnect upper intake manifold vacuum fitting connections by disconnecting:
   d. vacuum line to MAP sensor
   e. vacuum line to EGR valve
   f. vacuum line to fuel pressure regulator.
5. Disconnect EGR and PCV systems by disconnecting:
   g. EGR valve flange nut
   h. PCV hose at rear of upper manifold.



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6. Disconnect water heater lines from throttle body.



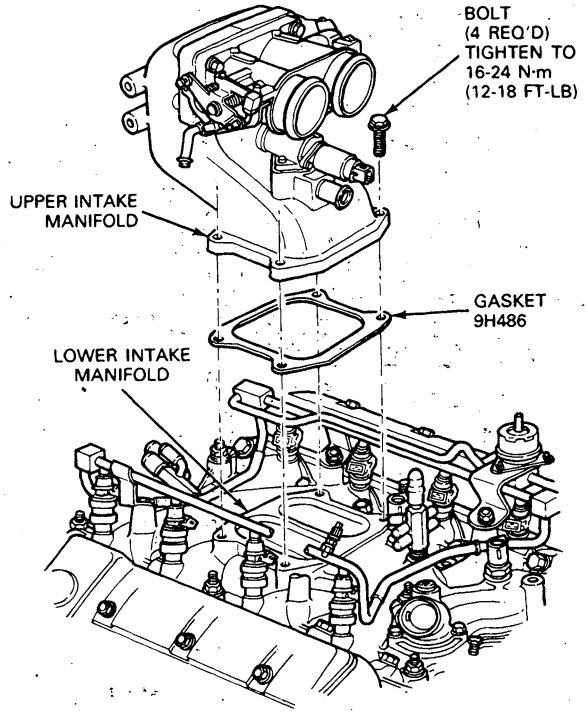


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REMOVAL AND INSTALLATION (Continued)

7. Remove four upper intake manifold retaining bolts.
8. Remove upper intake manifold and throttle body as an assembly.



Installation

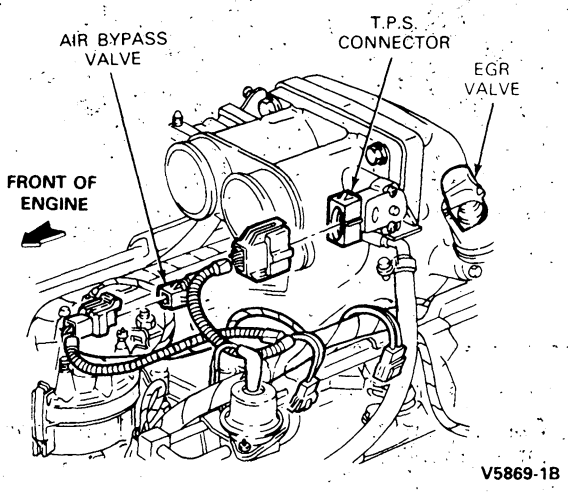
1. Clean and inspect the mounting faces of the lower and upper intake manifolds.
2. Position new gasket on lower intake mounting face. The use of alignment studs may be helpful.
3. Install upper intake manifold and throttle body assembly to lower manifold ensuring gasket remains in place (if alignment studs are not used).
4. Install four upper intake manifold retaining bolts. Tighten to specification.
5. Install EGR tube.
6. Connect water heater lines to the throttle body.
7. Connect PCV hose to rear of upper manifold.
8. Connect vacuum lines to MAP sensor, EGR valve, and fuel pressure regulator.
9. Position throttle linkage bracket with cables to upper intake manifold. Install two attaching bolts and tighten to specification. Connect throttle cable and AOD transmission cable to throttle body.
10. Connect electrical connectors at air bypass valve, TP sensor, and EGR position sensor.

NOTE: If lower intake manifold was removed, fill and bleed cooling system as outlined. Refer to Section 27-02, Cooling System Service.

Air Intake Throttle Body

Removal

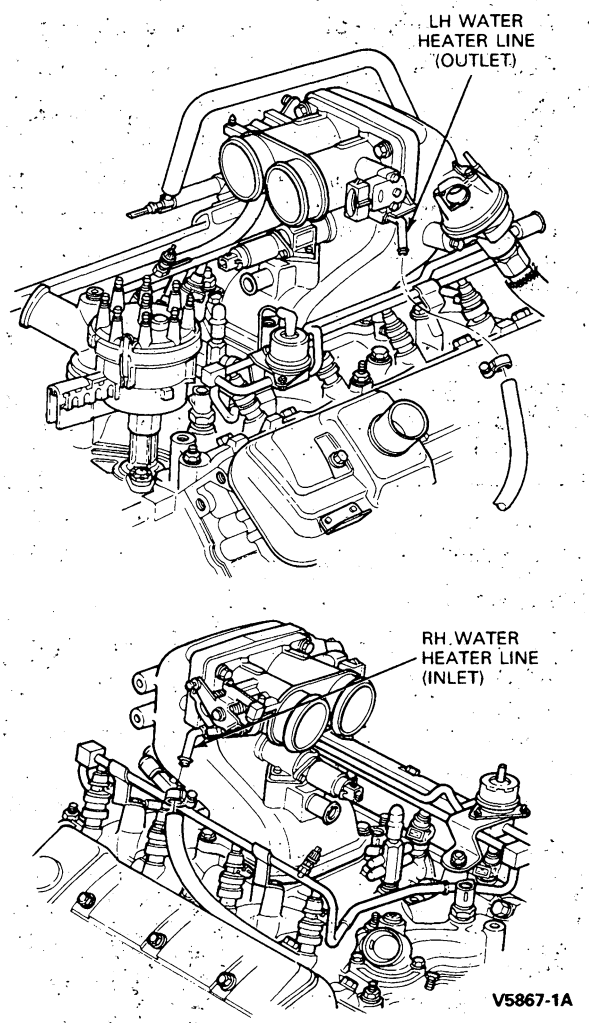
1. Disconnect electrical connector at throttle position sensor.



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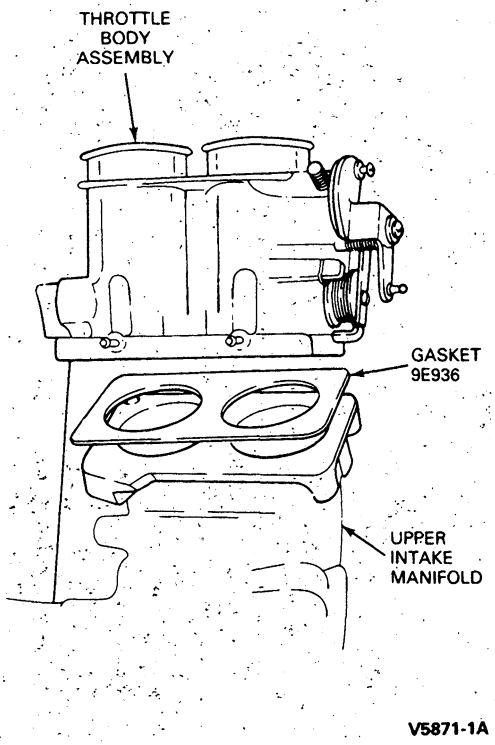
REMOVAL AND INSTALLATION (Continued)

2. Disconnect water heater lines from throttle body.



3. Remove four throttle body bolts.
4. Carefully separate air throttle body from upper intake manifold.

5. Remove and discard gasket between throttle body and upper intake manifold.



Installation

1. Ensure that both throttle body and upper intake manifold gasket surfaces are clean.

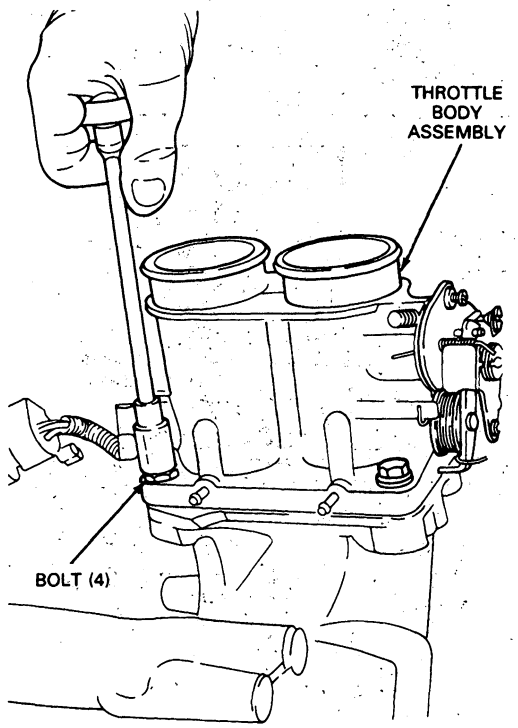
NOTE: If scraping is necessary, be careful not to damage gasket surfaces of throttle body and upper manifold assemblies, or allow material to drop into manifold.

2. Install throttle body gasket between upper intake manifold and throttle body. Make sure gasket stays in place if alignment studs are not used.
3. Install throttle body to upper intake manifold.

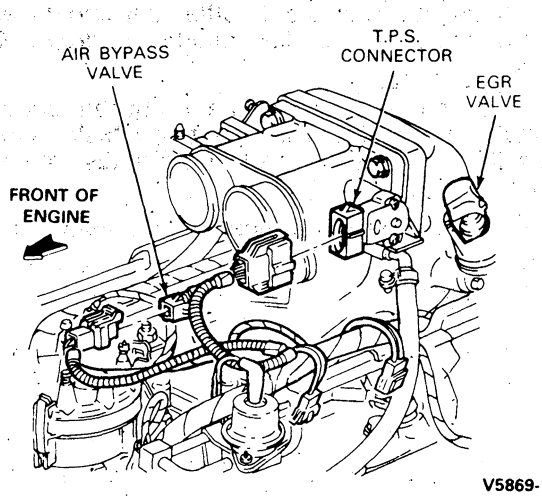
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REMOVAL AND INSTALLATION (Continued)

4. Secure throttle body assembly to upper intake manifold with four retaining bolts. Tighten to 15-24 N·m (12-18 ft-lb).



5. Connect water heater lines to throttle body.
6. Connect throttle position sensor electrical connectors.



Throttle Position Sensor

Removal

1. Disconnect throttle position sensor from wiring harness.
2. Scribe a reference mark across the edge of the sensor and to the throttle body to ensure correct position during installation.
3. Remove two throttle position sensor retaining screws.
4. Remove throttle position sensor.

Installation

1. Position throttle position sensor so that wiring connector is parallel to the venturi boxes. Then, rotate throttle position sensor clockwise to align scribe marks.
2. Secure sensor to throttle body assembly with two retaining screws. Tighten to 1.2-1.8 N·m (11-16 lb-in).

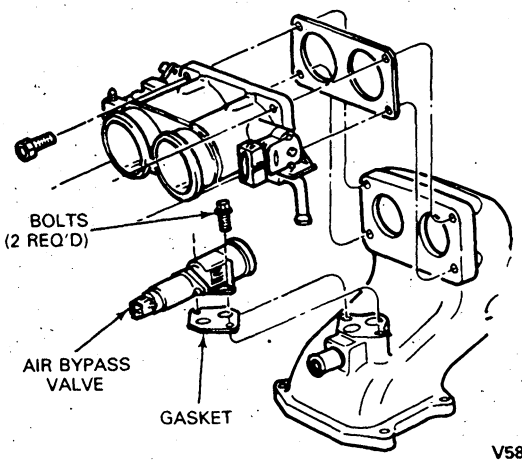
NOTE: When throttle position sensor is installed on the throttle body, the wiring connector should be pointing forward on the engine.

3. Connect electrical connector to harness.
4. Adjust throttle position sensor as described in Section 3 of the Engine/Emissions Diagnosis manual.*

Throttle Air Bypass Valve Assembly

Removal

1. Disconnect throttle air bypass valve assembly connector from wiring harness.
2. Remove two throttle bypass valve retaining bolts.
3. Remove throttle air bypass valve and gasket.



*Can be purchased as a separate item.

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REMOVAL AND INSTALLATION (Continued)

Installation

1. Ensure that upper intake manifold and throttle air bypass valve gasket surfaces are clean.

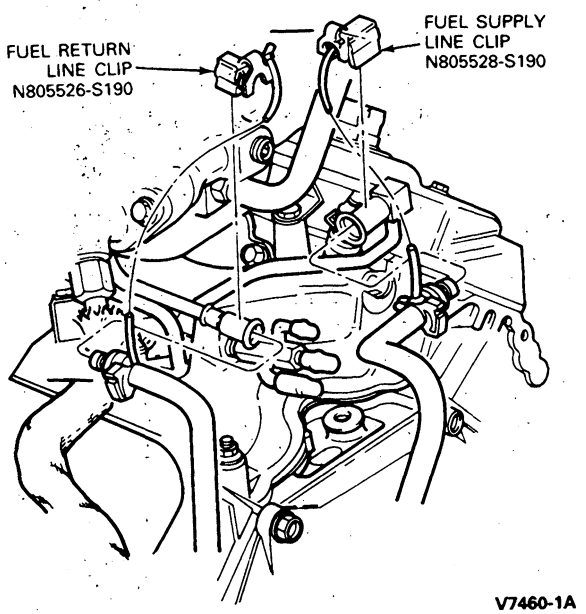
NOTE: If scraping is necessary, be careful not to damage throttle air bypass valve or intake manifold gasket surfaces, or drop material into intake manifold.

2. Install gasket and throttle air bypass valve on upper intake manifold surfaces.
3. Install retaining screws. Tighten to 8-11 N·m (71-102 lb-in).
4. Connect electrical connector for the throttle air bypass valve.

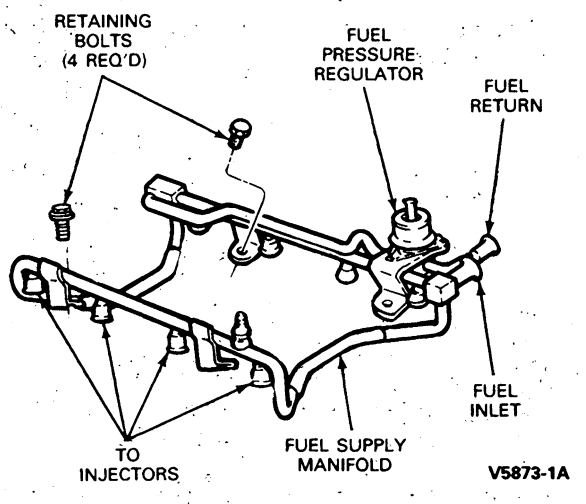
Fuel Supply Manifold Assembly

Removal

1. Perform Steps 1-4 under Fuel Charging Assembly.
2. Remove upper manifold assembly as outlined.
3. Relieve the fuel pressure. Refer to Section 24-50, Fuel Tank and Lines and Fuel Evaporative Emission Control System.
4. Remove fuel line to fuel rail retainer clips.

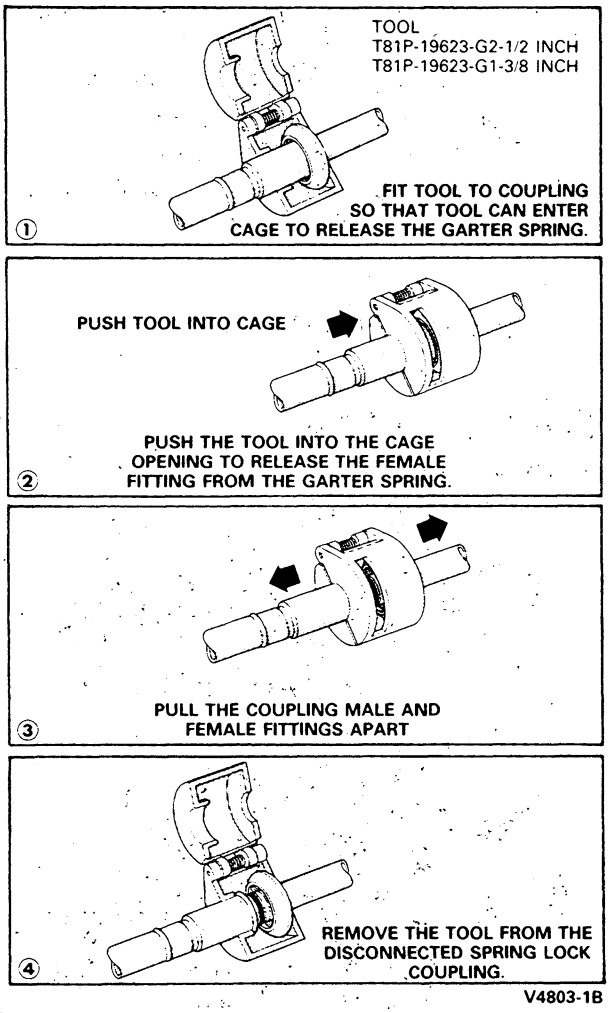


5. Using Quick Disconnect Tool D87L-9280-A or B or equivalents, disconnect fuel hoses at the fuel rail supply tube and fuel rail return tube.



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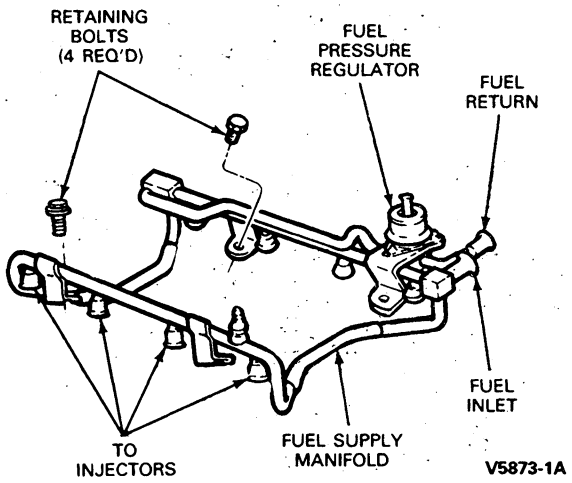
REMOVAL AND INSTALLATION (Continued)



5. Remove four (two per group) fuel supply manifold retaining bolts.
6. Carefully disengage manifold from fuel injectors and remove manifold.

Installation

1. Ensure injector caps are clean and free of contamination.
2. Place the fuel injector fuel supply manifold over each of the injectors and seat injectors into fuel supply manifold. Ensure injectors are well seated in the fuel manifold assembly.



3. Secure fuel manifold assembly using four retaining bolts. Tighten to 20-30 N·m (15-22 ft-lb).
4. Connect fuel inlet and outlet lines at fuel rail connections. Push in to connect.
5. Install fuel line to fuel rail clips.
6. Install upper intake manifold as outlined in this Section.

Fuel Pressure Regulator

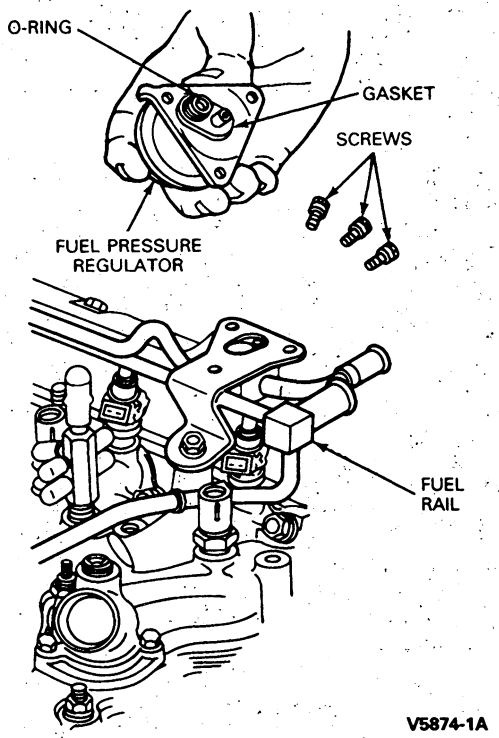
Removal

1. Perform Steps 1-4 under Fuel Charging Assembly Pre-Service Procedures if removing fuel pressure regulator while fuel supply manifold is installed on engine.
2. Remove vacuum line at pressure regulator.
3. Remove three socket head retaining screws from regulator housing.
4. Remove pressure regulator assembly, gasket and O-ring. Discard gasket and O-ring.

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REMOVAL AND INSTALLATION (Continued)

5. If scraping is necessary, be careful not to damage fuel pressure regulator or fuel supply line gasket surfaces.



Installation

1. Lubricate fuel pressure regulator O-ring with light oil ESF-M6C2-A or equivalent.

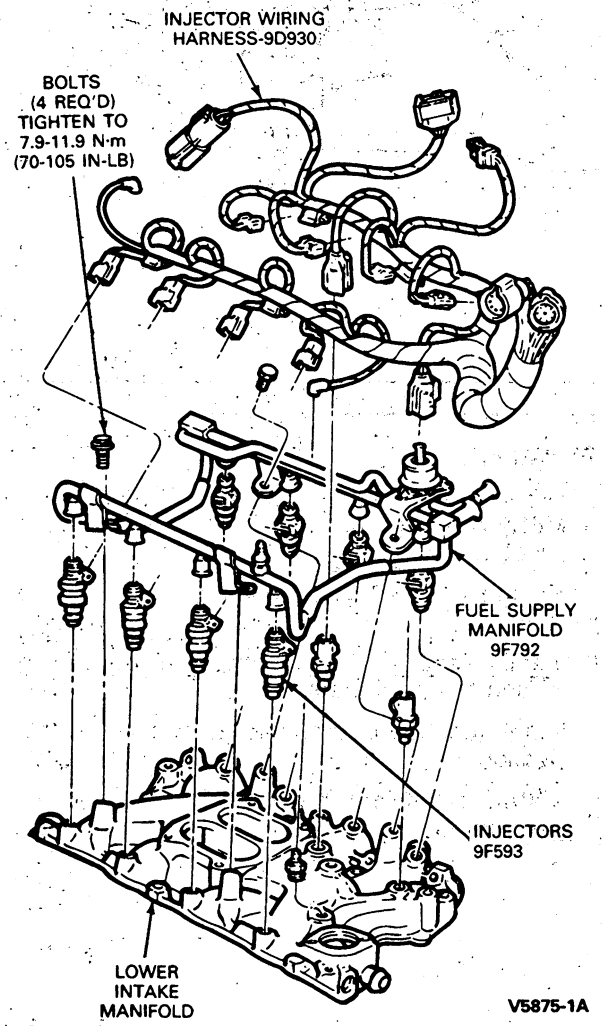
NOTE: Never use silicone lubricant. It will clog the injectors.

2. Ensure gasket surfaces of fuel pressure regulator and fuel injection manifold are clean.
3. Install a new O-ring and new gasket on regulator.
4. Install fuel pressure regulator on injector manifold. Tighten three retaining screws to 3.0-4.5 N·m (27-40 in-lb).
5. Install vacuum line to regulator.
6. Perform Steps 1-6 under Fuel Charging Assembly Post-Service Procedure.

Fuel Injector

Removal

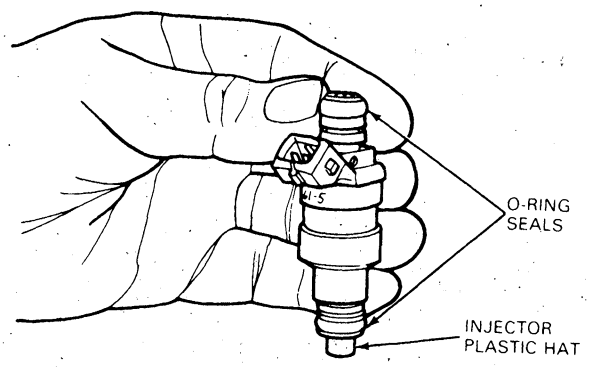
1. Perform Steps 1-4 under Fuel Charging Assembly Pre-Service Procedures.
2. Remove fuel supply manifold as outlined.
3. Carefully remove electrical harness connectors from individual injectors as required.
4. Grasping injector body, pull up while gently rocking injector from side-to-side.



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REMOVAL AND INSTALLATION (Continued)

5. Inspect injector O-rings (two per injector) for signs of deterioration. Replace as required.
6. Inspect injector "plastic hat" (covering the injector pintle) and washer for signs of deterioration. Replace as required. If hat is missing, look for it in intake manifold.



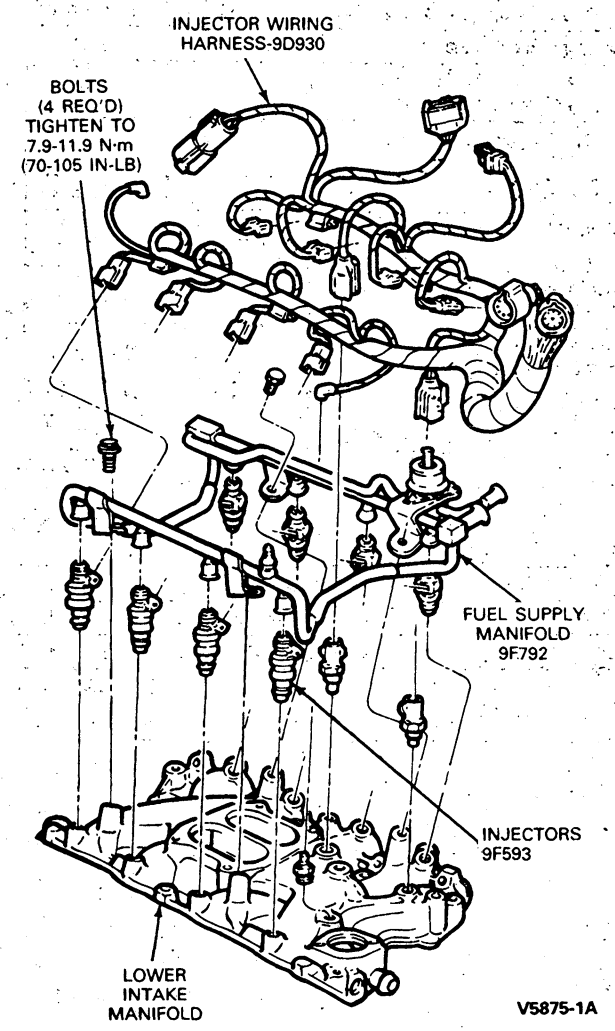
Installation

1. Lubricate new O-rings with light grade oil ESF-M6C2-A or equivalent and install two on each injector.

NOTE: Never use silicone lubricant. It will clog the injectors.

2. Install injector(s). Use a light, twisting, pushing motion to install them.
3. Install fuel supply manifold as outlined in this Section.
4. Install electrical harness connectors to injectors.

5. Install upper intake manifold as outlined. Perform Steps 1-4 of Fuel Charging Assembly Pre-Service Procedures.



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SPECIFICATIONS

TORQUE SPECIFICATIONS

Description	N-m	Ft-Lb
EGR Tube	34-47	25-35
EGR Valve to Upper Intake Manifold	8-11	70-100 in-lb
Air Supply Tube Clamps	1.3-2.25	12-20 in-lb
Upper Intake Manifold to Lower Intake Manifold Bolts	16-24	12-18
Throttle Body to Upper Intake Manifold	8-11	70-100 in-lb
Air Bypass Valve to Lower Manifold	8-11	70-100 in-lb
Throttle Position Sensor to Throttle Body	1.2-1.8	11-16 in-lb
Fuel Pressure Regulator to Injector Manifold	3-4.5	27-40 in-lb
Fuel Injector Manifold to Fuel Charging Assembly	8-12	70-105 in-lb
Coil Bracket to Platform	6-9.5	55-85 in-lb
Throttle Cable Bracket to Manifold	11-13	8-10

CV5876-1A

SPECIAL SERVICE TOOLS

Tool Number	Description
D87L-9280-B	Spring Lock Coupling Remover 1/2 Inch
D87L-9280-A	Spring Lock Coupling Remover 3/8 Inch

CV5877-1A

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SECTION 24-35 Fuel Pump—Electric

SUBJECT	PAGE
DESCRIPTION	
Fuel Pump Control	24-35-3
4.9L, 5.0L, 5.8L and 7.5L EFI Engines	24-35-1
DIAGNOSIS	
Dual Function Reservoir (Dual Tank)	24-35-5
EFI Fuel System Pressure and Flow Test Equipment	24-35-12
Electric Fuel Pump	24-35-8
DIAGNOSIS (Cont'd.)	
Inertia Switch	24-35-14
4.9L, 5.0L, 5.8L and 7.5L EFI Engines	24-35-12
High-Pressure Pump	24-35-12
Low-Pressure Pump	24-35-13
SPECIFICATIONS	24-35-14
VEHICLE APPLICATION	24-35-1

VEHICLE APPLICATION

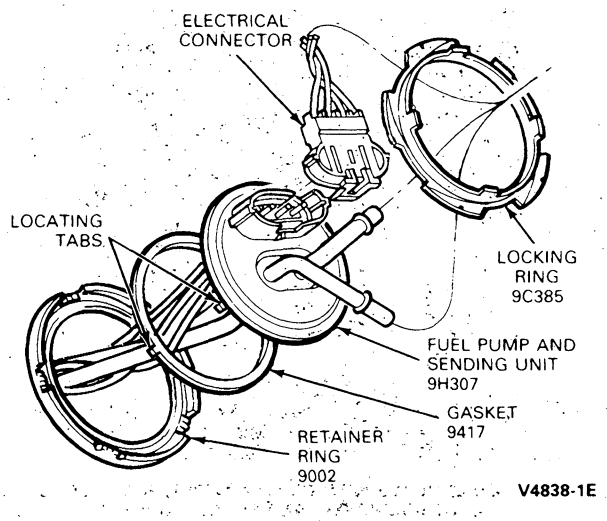
4.9L EFI, 5.0L EFI, 5.8L EFI and 7.5L EFI Engines with Electric Fuel Pump.

DESCRIPTION

4.9L, 5.0L, 5.8L and 7.5L EFI Engines

The electric fuel pump system used on the 4.9L, 5.0L, 5.8L and 7.5L Electronic Fuel Injection (EFI) engines consist of two fuel pumps: a low pressure boost pump mounted in the fuel tank, and a high pressure fuel pump mounted on the frame rail. An in-line reservoir is located at the high pressure pump inlet. This design provides for satisfactory fuel pump operation during extreme vehicle maneuvers and steep vehicle attitudes with low-tank fill levels.

The low pressure electric fuel pump is used to provide pressurized fuel to the inlet of the high pressure pump and helps prevent noise and hot fuel problems. The inlet of the low pressure fuel pump has a nylon filter on it to prevent dirt and other particulate matter from entering the system. Any water accumulation in the fuel tank can pass through the filter without restriction.

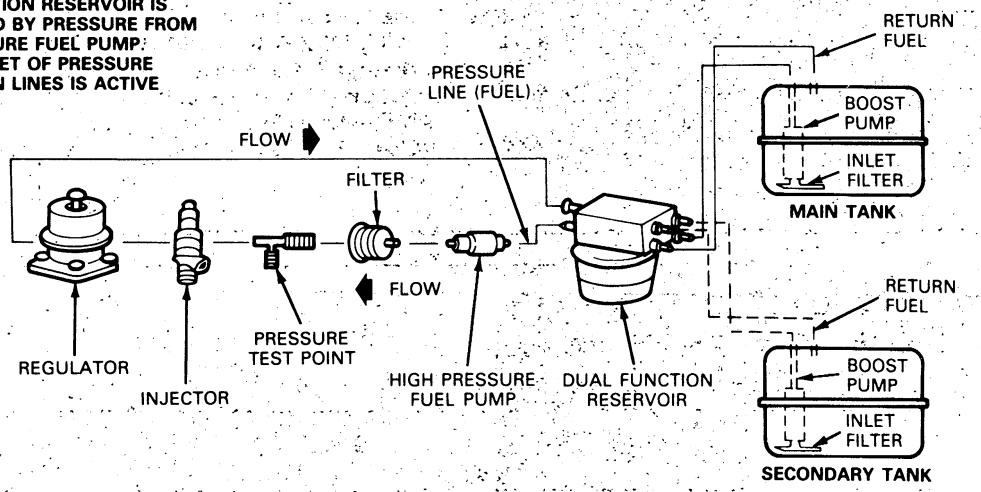


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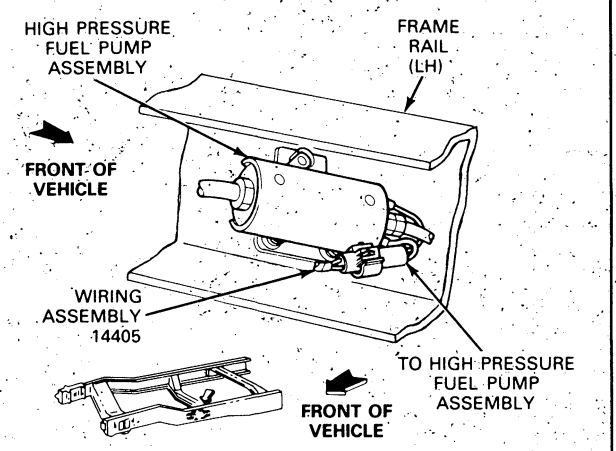
DESCRIPTION (Continued)

The externally mounted high pressure fuel pump is capable of supplying 80 liters (21.2 gallons) of fuel per hour at a working pressure of 269.0 kPa (39 psi) for the 5.0L and 5.8L EFI engines and 379.2 kPa (55 psi) for the 4.9L EFI engine. The pump has an internal pressure relief valve to provide overpressure protection in the event the fuel flow becomes restricted. Overpressure is restricted to 950 kPa (138 psi) and reduced fuel flow will result. The system pressure is controlled by a pressure regulator on the engine.

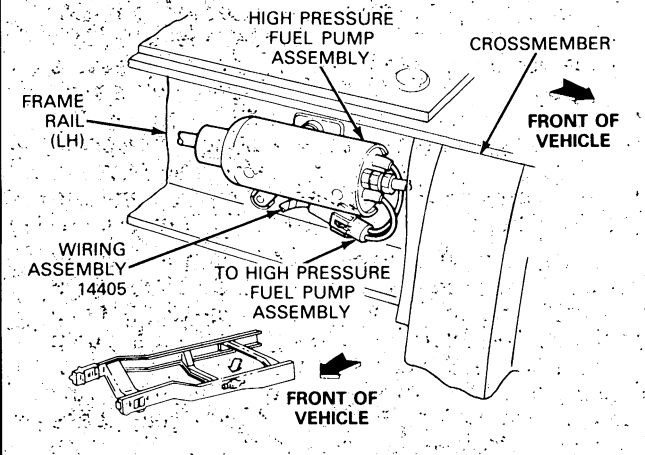
NOTE: DUAL FUNCTION RESERVOIR IS CONTROLLED BY PRESSURE FROM LOW PRESSURE FUEL PUMP. ONLY ONE SET OF PRESSURE AND RETURN LINES IS ACTIVE AT A TIME.



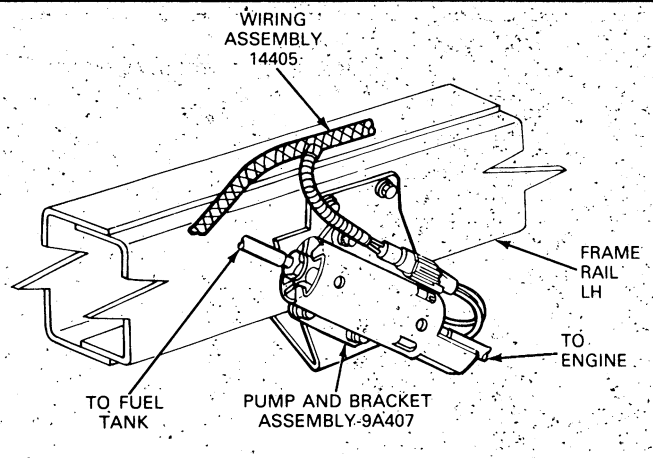
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VIEW SHOWING WIRING INSTALLATION FOR F-SERIES STANDARD CAB AND BRONCO MODELS



VIEW SHOWING WIRING INSTALLATION FOR F-SERIES CAB CHASSIS MODELS



VIEW SHOWING WIRING INSTALLATION FOR ECONOLINE MODELS

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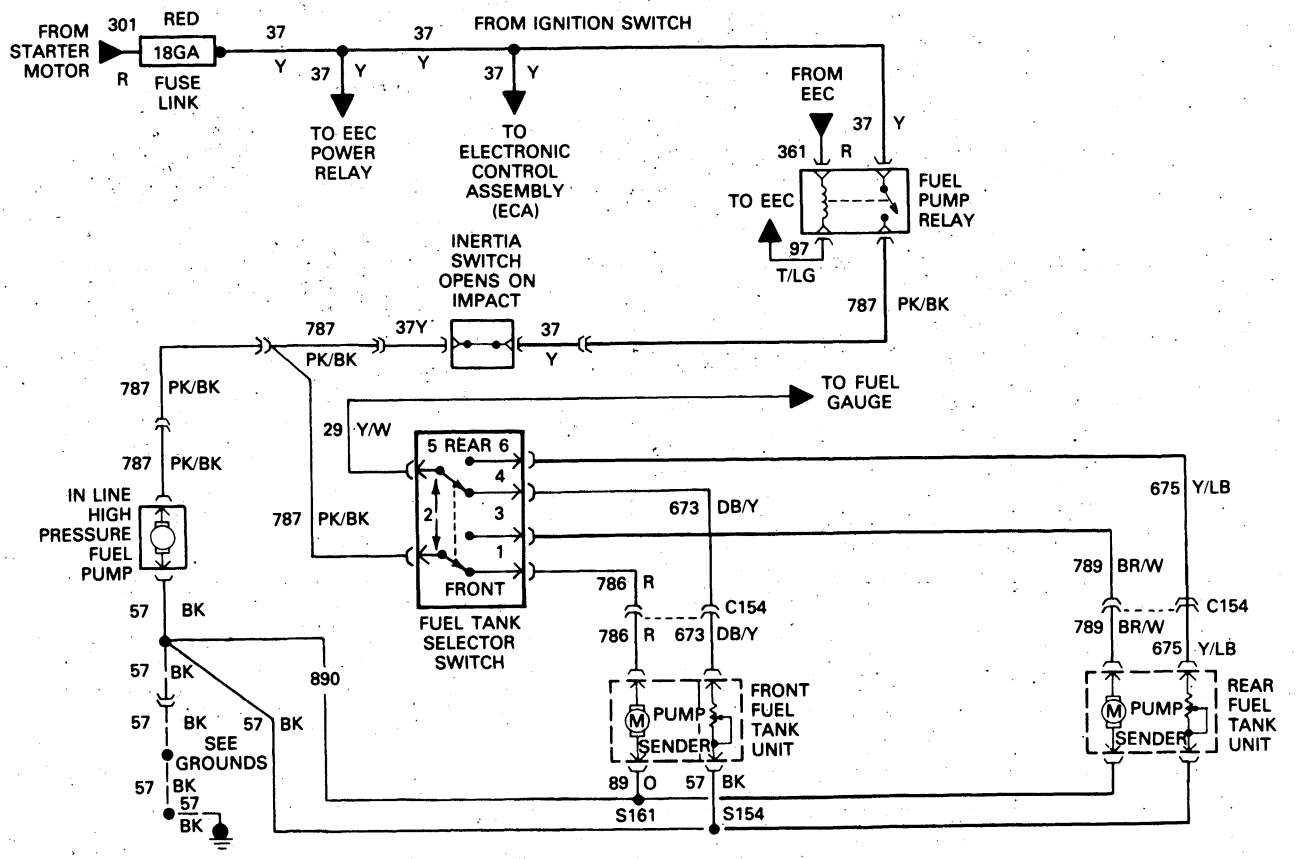
DESCRIPTION (Continued)

Fuel Pump Control

When the ignition switch is turned to the ON position, the Electronic Engine Control (EEC) power relay is energized and provides power to both the fuel pump relay and a timing device in the EEC processor. Fuel pump power is provided through the contacts of the fuel pump relay and the inertia switch. If the ignition switch is not turned to the START position within approximately one second, the timing device in the EEC processor will open the ground circuit (No. 57 bk) to the fuel pump relay. Opening the ground circuit de-energizes the fuel pump relay (opening its contacts), which de-energizes the fuel pumps. This circuitry pressurizes the fuel system.

When the ignition switch is turned to the START position, the EEC processor energizes the fuel pump relay to provide fuel while cranking.

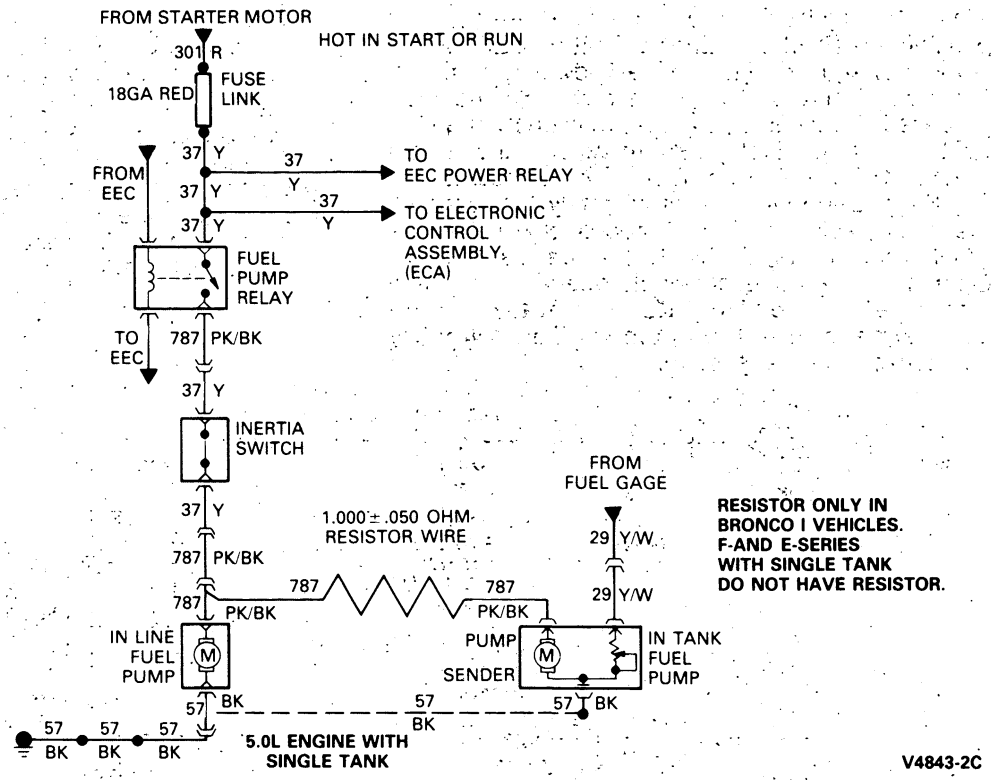
After the engine starts, the ignition switch is returned to the ON position, and power to the fuel pump is supplied through the fuel pump relay. The EEC processor senses speed and shuts off the fuel pump by opening the ground circuit (No. 57 bk) to the fuel pump relay if the engine stops or engine speed drops below 120 rpm.



E.F.I. ENGINE WITH DUAL TANKS V4841-2C

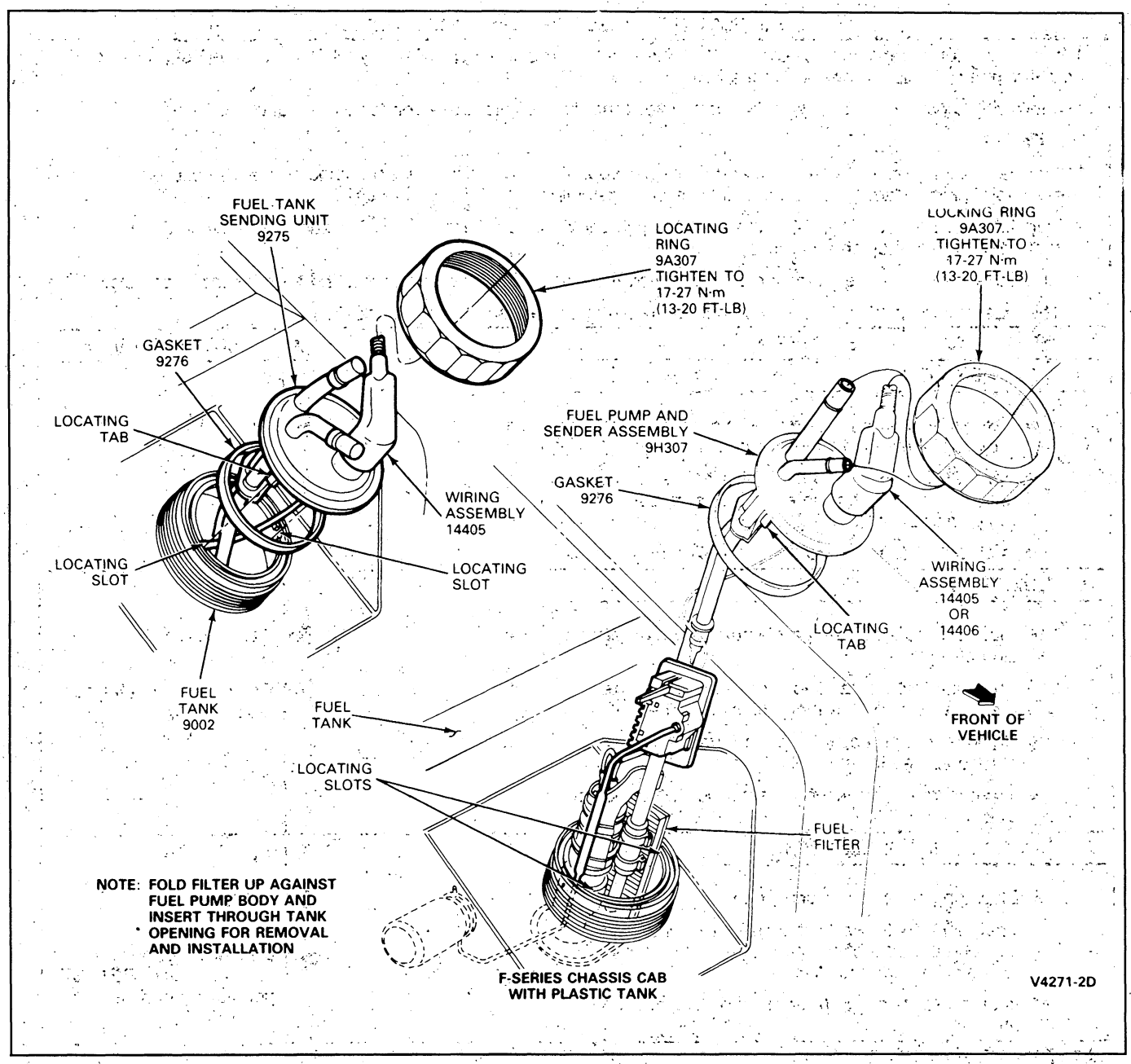
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DESCRIPTION (Continued)



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DESCRIPTION (Continued)



DIAGNOSIS

Dual Function Reservoir (Dual Tank)

The fuel tank selector valve on some vehicles is located in the fuel filter/reservoir mounted on the frame rail. This selector valve differs from previous units by not being electrically activated. The valve is operated by fuel pressure from the in-tank fuel pumps.

When the tank selector switch is in the FRONT position, power from the fuel pump relay is directed to the front tank fuel pump. When the tank selector switch is moved to the REAR position power from the fuel pump relay is directed to the rear tank fuel pump. Pressurized fuel from the fuel pump moves a diaphragm in the dual function reservoir which is connected to a sliding valve. The sliding valve allows fuel to be drawn from and returned to the correct fuel tank. This design relies on proper operation of the tank mounted low-pressure fuel pumps. A functional diagram and procedure for this reservoir is included.

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DIAGNOSIS (Continued)

DUAL FUNCTION RESERVOIR DIAGNOSIS GUIDE

The dual function reservoir is not serviceable. The reservoir requires approximately 13.8 kPa (2.0 psi) of pressure from the in-tank pumps to operate properly.

The following procedure should be followed to check the dual function reservoir for proper function:

NOTE:

1. For the following tests, it is recommended that appropriate sized quick connect fittings be used to connect to reservoir fittings. Damage to the port fittings may result if incorrect fittings are used.
2. Regulated air between 20.7-34.5 kPa (3 and 5 psi) should be used for testing. Pressure greater than 5 psi will rupture the internal diaphragm.
3. All brackets and fuel lines removed during testing must be secured as originally found after testing is completed.
4. The reservoir will contain fuel, care should be taken to prevent spillage or combustion.

TEST STEP	RESULT ▶	ACTION TO TAKE
A0 INITIAL CHECK		
• Remove lines from reservoir - note position and routing of lines, avoid fuel spillage. • Apply 20.7-34.5 kPa (3 to 5 psi) air to return port (small diameter tube) on engine side of reservoir (only one set of 2 ports). • Is air out of only one port on other side of reservoir?	Yes ▶ No ▶	GO to **A2**. GO to **A1**.
A1 RESET VALVE		
• Block pressure port (large diameter tube) on engine side of unit. • Apply 20.7-34.5 kPa (3 to 5 psi) to either of the pressure ports on the fuel tank side of the unit. • Remove air and apply to return tube on engine side of reservoir as in Step **A0**. • Is pressure out of only one return port on the other side of the unit?	Yes ▶ No ▶	GO to **A2**. REPLACE unit (valves stuck).
A2 CHECK SWITCHING ACTION		
• Block engine pressure port of unit. • Apply 20.7-34.5 kPa (3 to 5 psi) air to one pressure port and the corresponding return port on the fuel tank side of the unit. • Is air pressure out or return port on engine side of unit?	Yes ▶ No ▶	GO to **A3**. Change to opposite return port and RETEST per **A2**. If unit fails, REPLACE
A3 VALVE SWITCHING		
• Remove air from pressure port tested previously and apply air to other set of ports on unit. • Is air pressure out of return port on engine side?	Yes ▶ No ▶	GO to **A4**. CHECK connection to return port, if port correct then REPLACE unit (valves stuck).

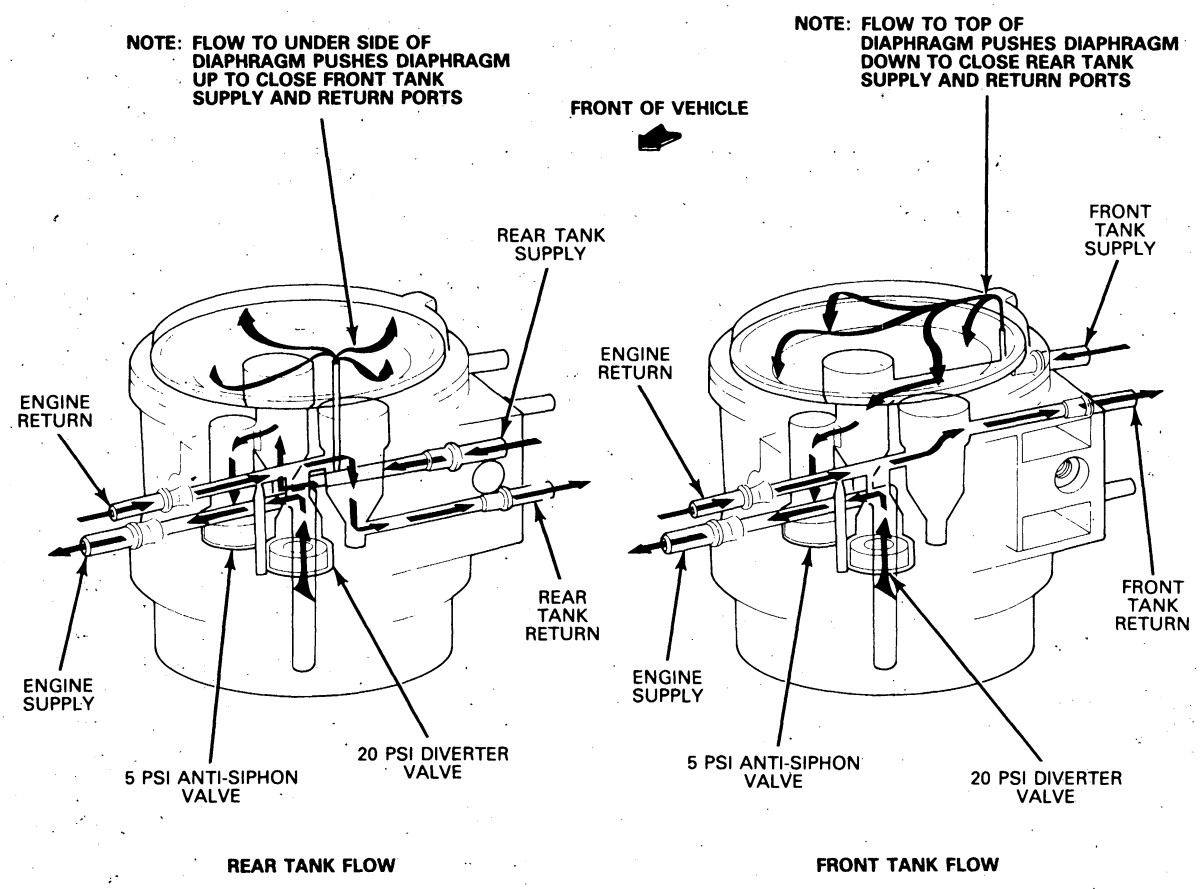
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DIAGNOSIS (Continued)

DUAL FUNCTION RESERVOIR DIAGNOSIS GUIDE (Continued)

TEST STEP		RESULT	ACTION TO TAKE
A4	CHECK LEAKAGE		
• Remove any blockages installed in the unit. • Apply pressure to the engine side pressure port and note which port is open on the fuel tank side of the unit. • Attach a pressure gauge (0 to 110 inches of water) to the closed pressure port. • Block the open port on the tank side of the unit. • Is pressure present on the gauge?		Yes ▶ No ▶	REPLACE unit (leakage between valves). GO to **A5**.
A5	LEAKAGE TEST		
• Remove pressure and gauge from selected port in Step **A4**. • Attach gauge to closed return port. • Apply pressure to return port on engine side and block open return port. • Is pressure on gauge?		Yes ▶ No ▶	REPLACE unit (leakage). Unit OK.



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DIAGNOSIS (Continued)

Electric Fuel Pump

Almost any electric fuel pump malfunction that can occur will result in a reduction of fuel flow and/or pressure. A reduction of fuel flow and/or pressure will be detected by a reduction in engine performance. This diagnostic procedure will concentrate on determining if the electric fuel pump system is operating properly. Other diagnostic procedures will cover the analysis of other malfunctions that can cause losses or reductions of engine performance.

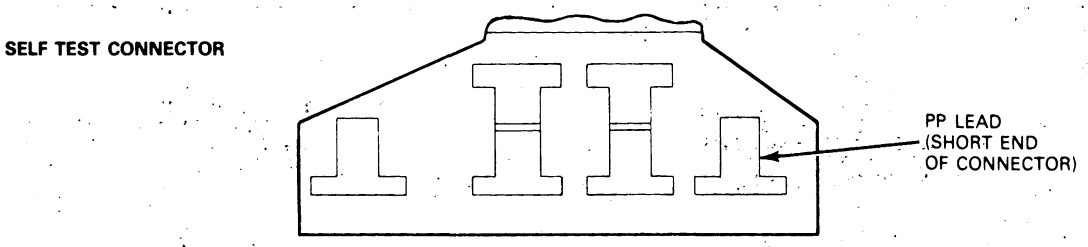
The following diagnostic procedures are to be performed to determine if the electric fuel pumps are operating correctly:

NOTE: If no pressure is detected in fuel lines during test procedure, fuel pump should not be powered in excess of three minutes to avoid possible overheating of pump.

A separate procedure is included to test low-pressure electric fuel pumps. It is only necessary to test low-pressure pumps if noise or very low flow is a problem with two-pump systems.

ELECTRIC FUEL PUMP DIAGNOSIS GUIDE — 1989 LIGHT TRUCK ENGINES

Engine Condition	4.9L EFI	5.0L EFI	5.8L EFI	7.5L EFI
Engine Running	45-60 PSI	30-45 PSI	30-45 PSI	30-45 PSI
	310-415 kPa	210-310 kPa	210-310 kPa	210-310 kPa
Key ON Engine OFF	50-60 PSI	35-45 PSI	35-45 PSI	35-45 PSI
	345-415 kPa	210-310 kPa	210-310 kPa	210-310 kPa



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DIAGNOSIS (Continued)

ELECTRIC FUEL PUMP DIAGNOSIS GUIDE — HIGH PRESSURE

TEST STEP		RESULT	ACTION TO TAKE
B0	CHECK STATIC FUEL PRESSURE		
	• Check for adequate fuel supply. • Key off. • Install fuel pressure gauge. • Install test lead to FP lead of VIP test connector. • Turn key to RUN position. • Ground test lead to run fuel pump. • Refer to Fuel Pressure Specification Table and check to determine if pressure is within acceptable limits.	Yes ▶ No ▶	GO to **B4**. GO to **B1**.
B1	HYDRAULIC CIRCUIT CHECK		
	• Pressure low but greater than 20.7 kPa (3 psi) (indicates fuel pump is running but not enough pressure).	Yes ▶ No ▶	GO to **B2**. GO to **B3**.
B2	HYDRAULIC CIRCUIT CHECK		
	• Plugged fuel line filter (replace filter and check again for proper pressure). • Kinked/restricted fuel lines (visual inspection). • Low voltage to fuel pump (should be within 0.5 volts of battery voltage at connector). • Disconnect return fuel line and note if fuel is being returned during this low pressure condition. If fuel is being returned, replace or adjust pressure regulator.	Yes ▶ No ▶	If service was required and made, GO to **B0**. If no service was required, replace fuel pump and GO to Step **B0**.
B3	ELECTRICAL CIRCUIT CHECK		
	• Inertia switch open? (reset switch as required) • Wiring at fuel pump/tank connector loose or open? • Fuel pump ground connection at chassis loose or defective? • Improper fuel pump relay operation (should operate when FP (test) lead is grounded with ignition key in RUN position). • EEC relay not operating if Fuel Pump Relay doesn't operate?	Yes ▶ No ▶	SERVICE all electrical problems and RETURN to Step **B0**. If no electrical defects have been found, and pump still won't run, REPLACE pump and RETEST per Step **B0**.
B4	CHECK VALVE TEST		
	• Remove ground from test lead and note pressure on gauge. Pressure should remain within 20.7 kPa (2 psi) for 3 minutes after lead is ungrounded.	Yes ▶ No ▶	GO to **B6**. GO to **B5**.

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DIAGNOSIS (Continued)

ELECTRIC FUEL PUMP DIAGNOSIS GUIDE — HIGH PRESSURE (Continued)

TEST STEP		RESULT	ACTION TO TAKE
B5	CHECK LEAK CHECK		
• Fuel lines or connectors leaking? • Disconnect fuel return line and plug engine side. Momentarily activate fuel pump by grounding test lead. Raise pressure to approximate operating pressure. Repeat Step **B4**. If pressure holds, replace regulator and repeat Test **B4**.		Yes ▶ No ▶	If service was made, GO to Step **B0**. If no problems were found, REPLACE fuel pump and GO to Step **B0**. If unit still fails Step **B4**, there may be a leaking fuel injector or rail. CORRECT these problems and GO to Step **B4**.
B6	ENGINE ON TEST		
• If engine is EFI (fuel rail injectors), disconnect and plug the vacuum line connected to the pressure regulator. • Start engine and run at idle. Fuel pressure should be as indicated in chart for Key On, Engine Off.		Yes ▶ No ▶	GO to **B8**. GO to **B7**.
B7	IDLE ENGINE REPAIR		
• Fuel filter restricted (replace)? • Improper fuel regulator adjustment? • Fuel line restricted? • Improper voltage to fuel pump (battery voltage at pump connections)?		Yes ▶ No ▶	If defect has been found and serviced, GO to **B0**. If no defect is found, REPLACE fuel pump and GO to **B0**.
B8	HIGH SPEED TEST		
• With engine running at idle and vacuum line disconnected if necessary from Step B6, note fuel rail pressure. • Rapidly accelerate engine and watch fuel pressure. Does pressure remain within 5 psi of starting pressure? **NOTE:** Road testing vehicle while monitoring pressure may give a better test under load conditions.		Yes ▶ No ▶	Fuel pump is OK. If problem persists, CONSULT other parts of the manual. DISCONNECT test connections and RECONNECT vacuum lead if removed for test. GO to **B7**.

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DIAGNOSIS (Continued)

ELECTRIC FUEL PUMP DIAGNOSIS GUIDE — LOW PESSURE

NOTE:

1. If you have multiple fuel tanks on vehicles, it will be necessary to perform this test on both fuel tanks to assure proper operation of both low pressure fuel pumps.
2. It has been observed that if the low pressure pump is running, it is almost certain that it is operating correctly. Therefore, flow testing of the fuel pump is only necessary if there is a good reason to suspect pump damage which would cause the pump to 'run but not pump'.
3. All tests should be performed with a fully charged vehicle battery. Fuel pump flow is very susceptible to vehicle voltage.

TEST STEP	RESULT ▶	ACTION TO TAKE
C0 INITIAL SET-UP AND TEST		
• Attach test lead to FP lead on VIP test connector (under "ELECTRIC FUEL PUMP DIAGNOSIS"), make sure lead is long enough to reach work area under vehicle. • Turn ignition key to RUN position. • Raise vehicle on hoist and bring test lead to a convenient point for grounding. • Ground test lead and listen at fuel tank for low-pressure pump operation (a stethoscope or other device will help to hear pump). The electrical connection may be disconnected to the high-pressure pump to aid in hearing the pump run. • Is pump running?	Yes ▶ No ▶	GO to **C1**. GO to **C2**.
C1 FLOW TEST		
• Remove ground from test lead. • Disconnect pressure line from pump at reservoir inlet fitting. • Obtain a calibrated container of at least one quart capacity. • Place fuel line removed from reservoir into container. • Ground test lead and run pump for 5 seconds. • Is fuel level at least 6 ounces (180 ml)?	Yes ▶ No ▶	Fuel pump OK. REINSTALL lines and REMOVE test connections. Momentarily restrict line to provide back pressure to prime pump. If no flow develops, CHECK for blocked lines and REPLACE pump if no problem found.
C2 ELECTRICAL CHECK		
• If high-pressure pump is not running, check inertia switch, test connections, fuel pump relay, and any other wiring problems which could prevent the pumps from activating. Both pumps run from the same electrical circuit. • If high-pressure pump runs, check connections at top of fuel tank to pump for continuity and for voltage when circuit is energized. • Was electrical problem found?	Yes ▶ No ▶	SERVICE problems found and REPEAT Step **C0**. REPLACE pump.

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DIAGNOSIS (Continued)

EFI Fuel System Pressure and Flow Test Equipment

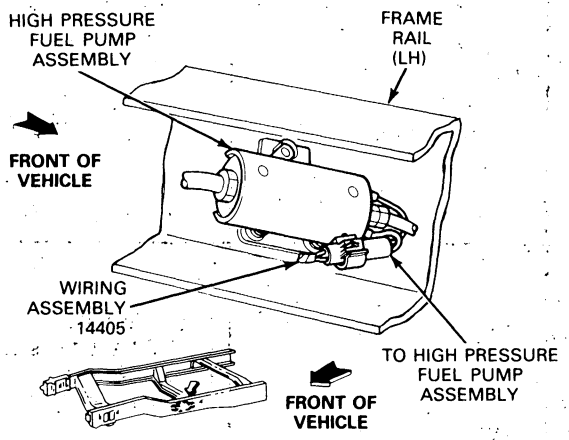
Use Adapter D85L-9974-B and Fuel Pressure Gauge D80L-9974-B or equivalent to test the EFI Fuel System electric fuel pump.

4.9L, 5.0L, 5.8L and 7.5L EFI Engines

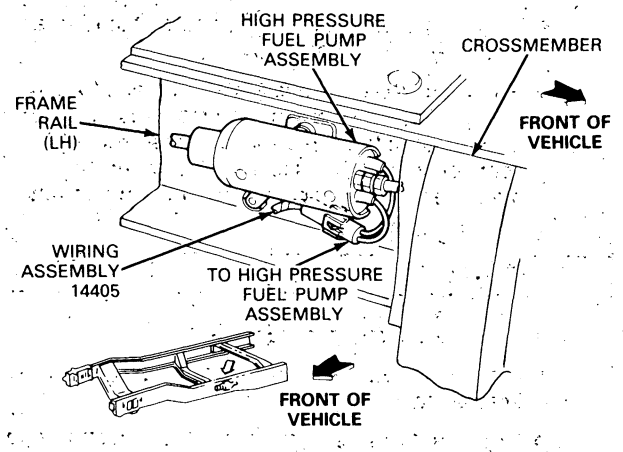
High-Pressure Pump

Replacement

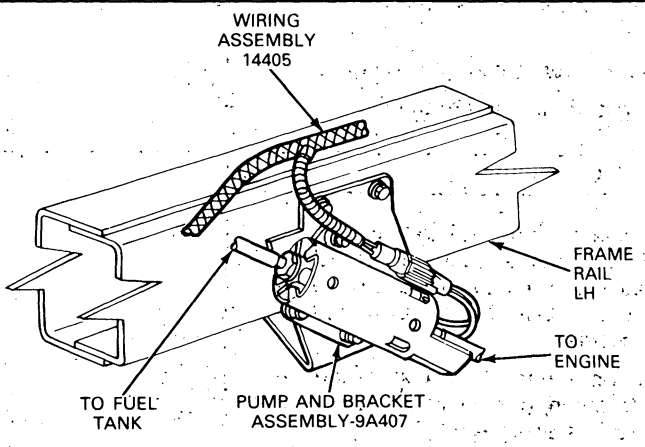
The high-pressure fuel pump is frame mounted and can be accessed from under the vehicle. Before removing the fuel pump, relieve the pressure in the fuel system using Fuel Pressure Gauge T80L-9974-B or equivalent on the feeler diagnostic valve, or by opening the electrical circuit to the fuel pump and cranking the vehicle for a minimum of 20 seconds. Refer to Section 24-50, Fuel Tanks and Lines, for Fuel System Pressure Relief, and Push Connect Fitting procedures.



VIEW SHOWING WIRING INSTALLATION FOR F-SERIES STANDARD CAB AND BRONCO MODELS



VIEW SHOWING WIRING INSTALLATION FOR F-SERIES CAB CHASSIS MODELS



VIEW SHOWING WIRING INSTALLATION FOR ECONOLINE MODELS

V5887-2B

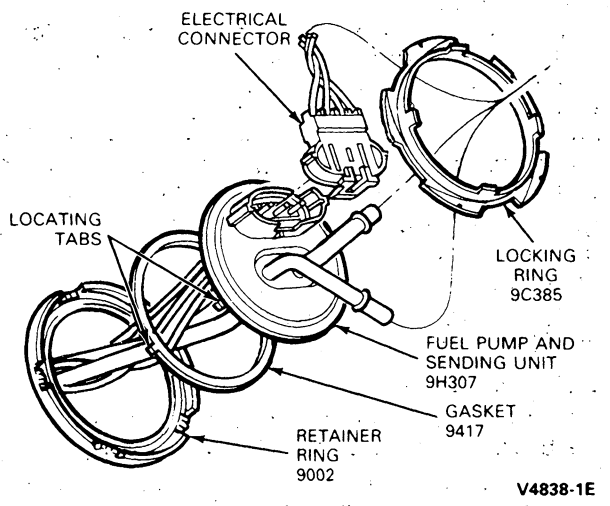
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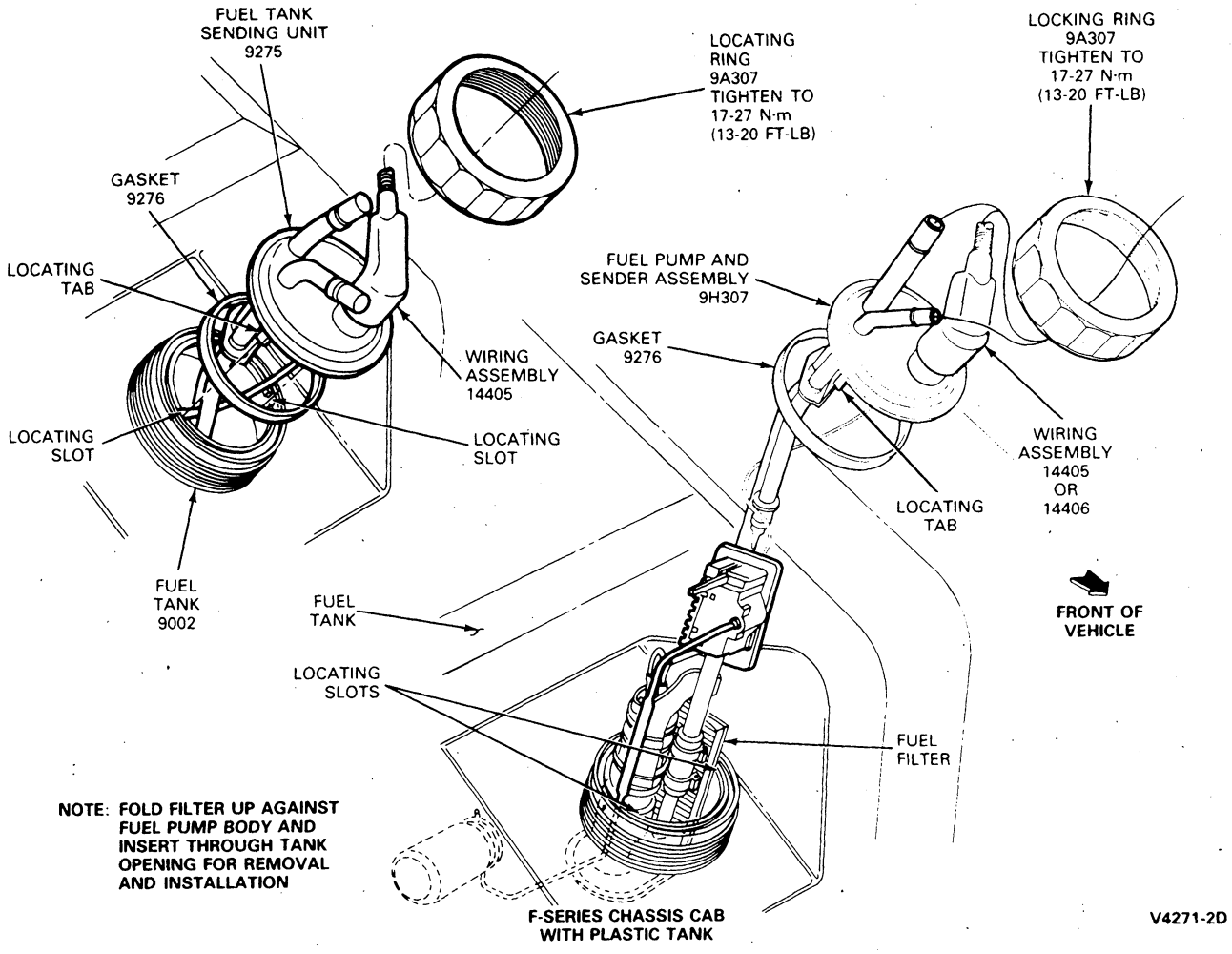
DIAGNOSIS (Continued)

Low-Pressure Pump

Replacement

The low-pressure pump is located in the fuel tank and may require removal of the fuel tank for replacement. Refer to Section 24-50, Fuel Tanks and Lines, for fuel tank removal and installation. Refer to Section 33-20, Fuel Indicating Systems, for fuel pump-sender assembly removal and installation procedure (same as for sender only).





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DIAGNOSIS (Continued)

Inertia Switch

In the event of a collision, the electrical contacts in the inertia switch open and the fuel pump automatically shuts off. The fuel pump will shut off even if the engine does not stop running. The engine, however, will stop a few seconds after the fuel pump stops. It is not possible to restart the engine until the inertia switch is manually reset.

CAUTION: Do not reset the inertia switch until the complete fuel system has been inspected for leaks.

To reset the inertia switch, depress the button on top of the switch.

Switch Location

On F-Series the switch is on the far left part of the toe-board, near the parking brake assembly.

On E-Series the switch is on the passenger side cowl panel, just forward of the right front door.

WARNING: IF YOU SEE OR SMELL GASOLINE AT ANY TIME OTHER THAN DURING FUELING, DO NOT RESET THE SWITCH.

SPECIFICATIONS

TORQUE SPECIFICATIONS

Description	N-m	Ft-Lb
Fuel Line Fittings	13-20	10-15

CV4232-1B

Tool Number	Description
T80L-9974-B	Fuel Pressure Gauge
D85L-9974-B	Adapter
T80L-9974-B	Fuel Pressure Gauge

CV4233-1F

ROTUNDA EQUIPMENT

Number	Description
014-00407	Digital Volt-Ohmmeter
018-00003	Safety Can

CV5579-1B

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SECTION 24-41 Air Cleaners—Dry Type

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Air Cleaner	24-41-1
REMOVAL AND INSTALLATION (Cont'd)	
EFI Engines	24-41-1
VEHICLE APPLICATION	24-41-1

VEHICLE APPLICATION

All Light Truck Models Equipped with Gasoline Engines.

DESCRIPTION

Air Cleaner

Dry-type air cleaners are standard on F-150 through F-350 and F-Super Duty series, Bronco and E-150—E-350 series vehicles.

Air enters the air cleaner and travels through a chemically treated and pleated paper element before entering the engine induction system. The air filter element should be inspected, cleaned, or replaced periodically according to the schedule in Section 10-02, Maintenance. The air cleaner system has a heat sensor mounted in the cleaner assembly to control engine inlet air temperature (on some models).

REMOVAL AND INSTALLATION

Air Cleaner

Refer to Figs. 1 through 7 for removal and installation of the various types of air cleaners. Reference to the illustrations will enable the service technician to perform the required removal and installation and/or repair operations. For all engines refer to the following procedure.

EFI Engines

Refer to Figs. 1 through 7.

Removal

1. Loosen two hose clamps securing hose assembly to air cleaner.
2. Remove two screws attaching air cleaner to bracket.
3. Disconnect hose and inlet tube from air cleaner.
4. Remove screws attaching air cleaner cover.
5. Remove air filter and tubes.

Installation

1. Set air filter into proper position.
2. Position A/C cover to tray. Ensure filter is seated while positioning cover.
3. Install screws to secure cover.
4. Install two bolts to secure air cleaner to support bracket.
5. Install fresh air inlet tube to air cleaner.
6. Install air supply tube to air cleaner and retain with clamps. Tighten clamps to specifications.

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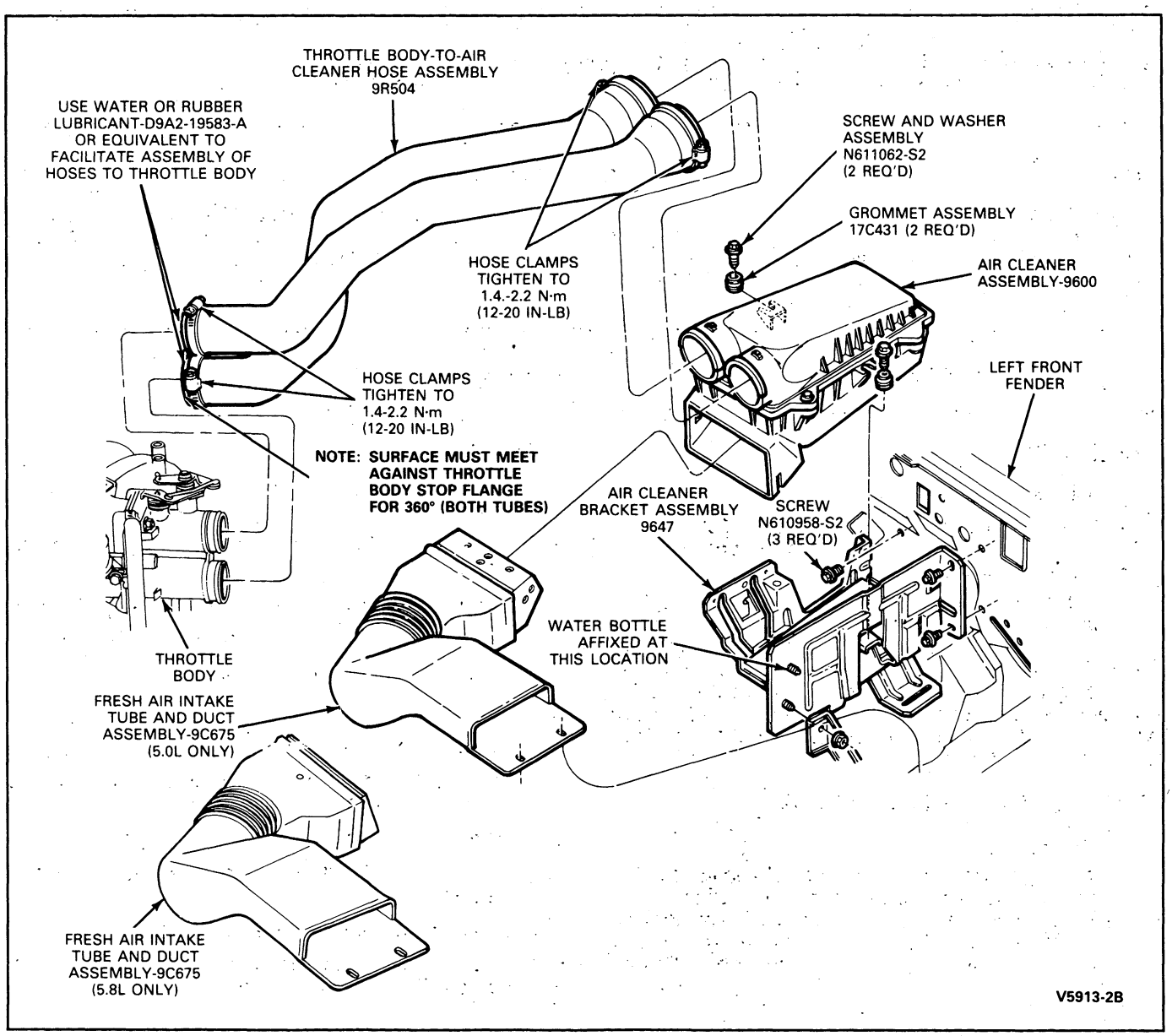


FIG. 1 Typical Air Cleaner Installation—F-150—F-250 and Bronco—5.0L 5.8LW EFI Engine

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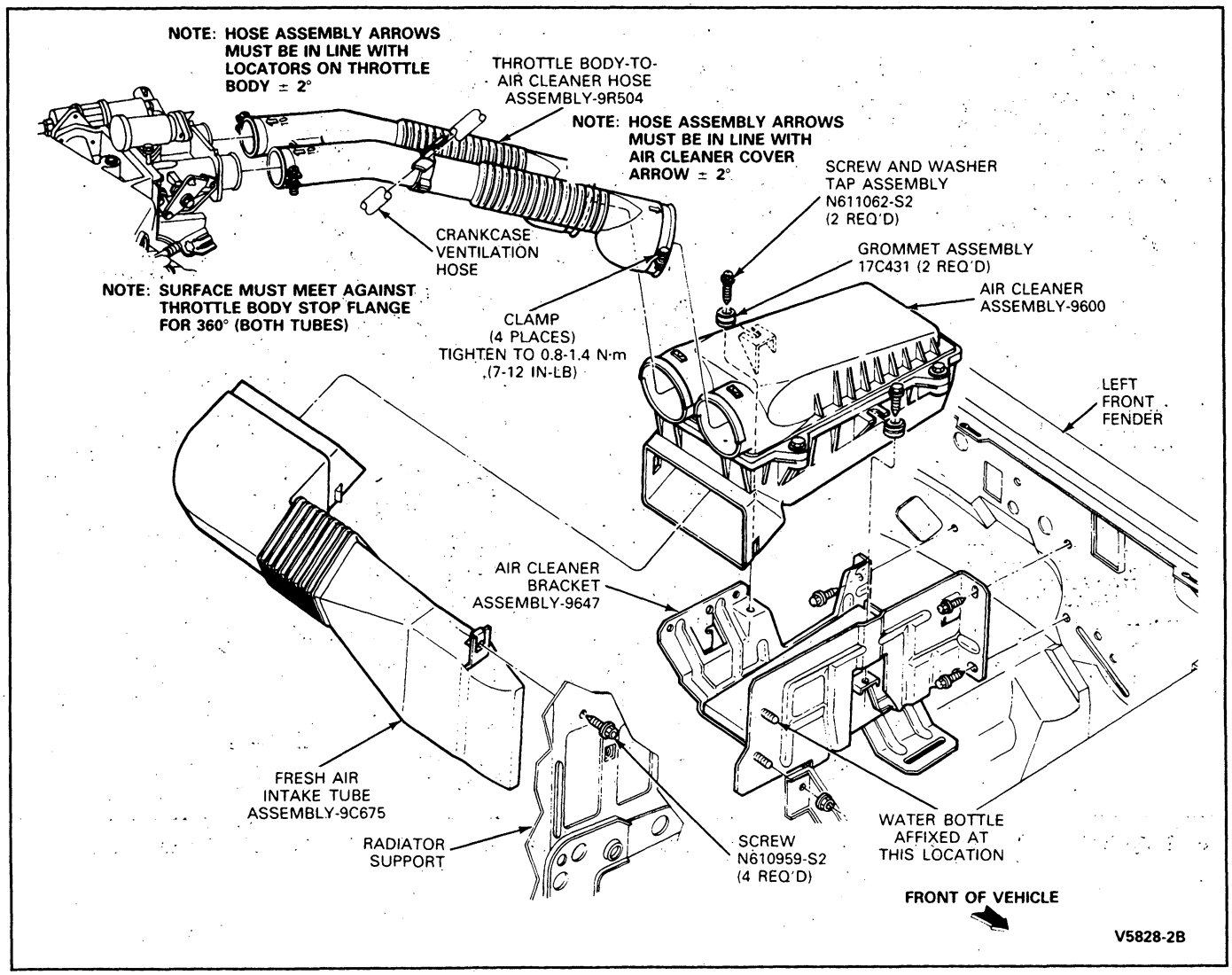


FIG. 2 Typical Air Cleaner Installation for F-150—F-350 and Bronco—4.9L EFI Engine

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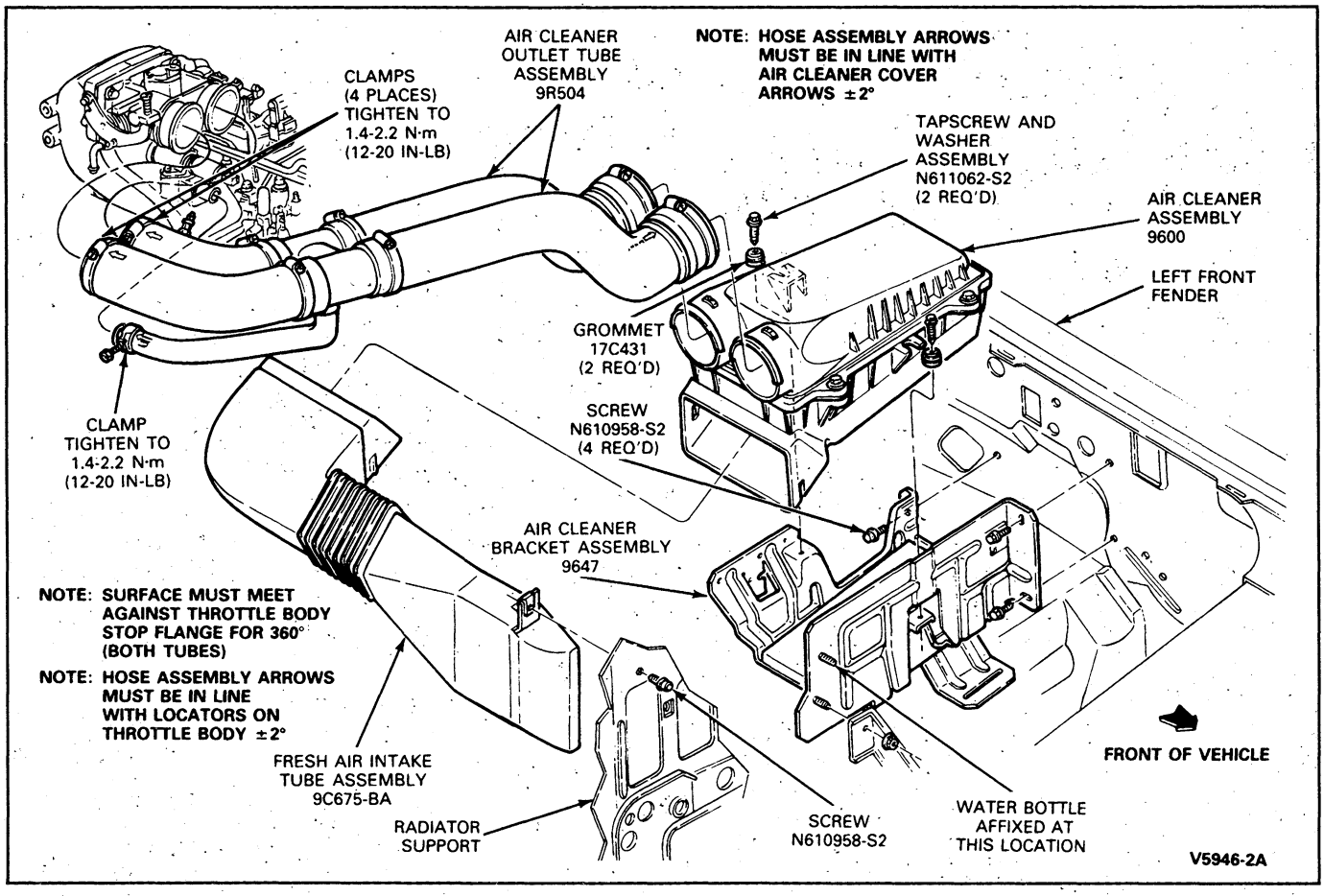


FIG. 3 Typical Air Cleaner Installation for F-250—F-350 and F-Super Duty—7.5L (460 CID) EFI V-8 Engine

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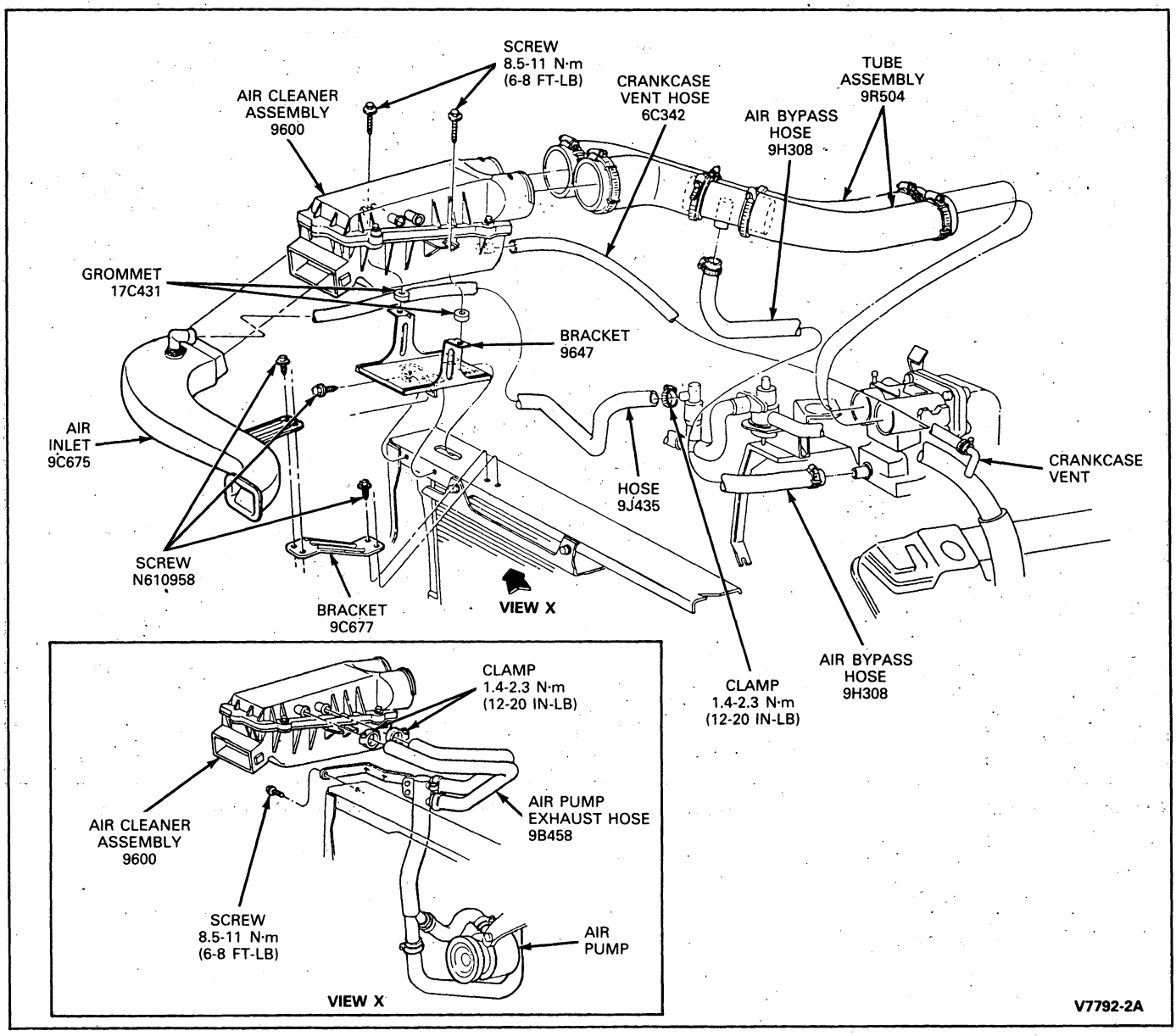


FIG. 4 Air Cleaner Installation—F-Super Duty Motor Home Chassis—7.5L EFI Engine

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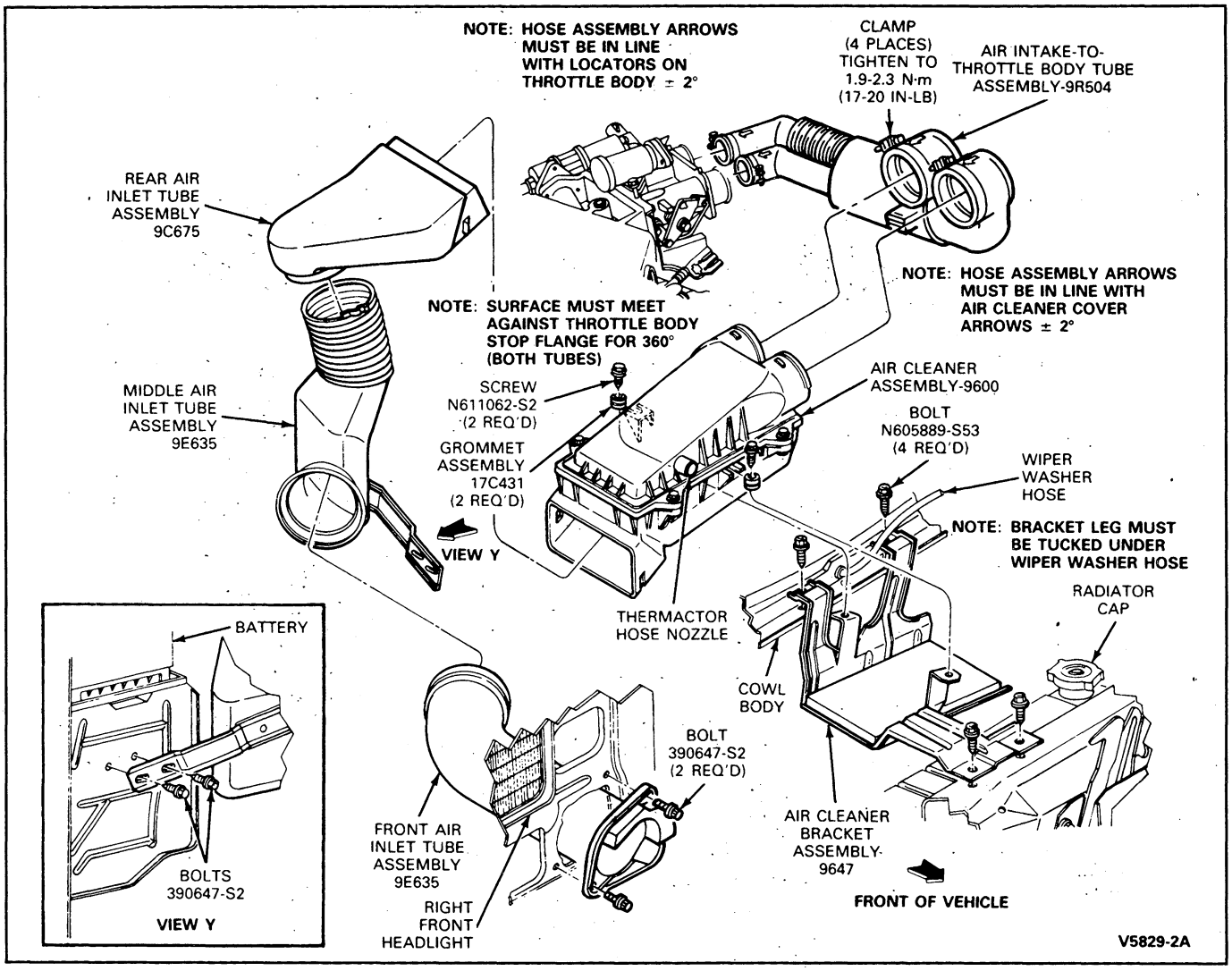


FIG. 5 Typical Air Cleaner Installation for E-150—E-350—4.9L EFI Engine

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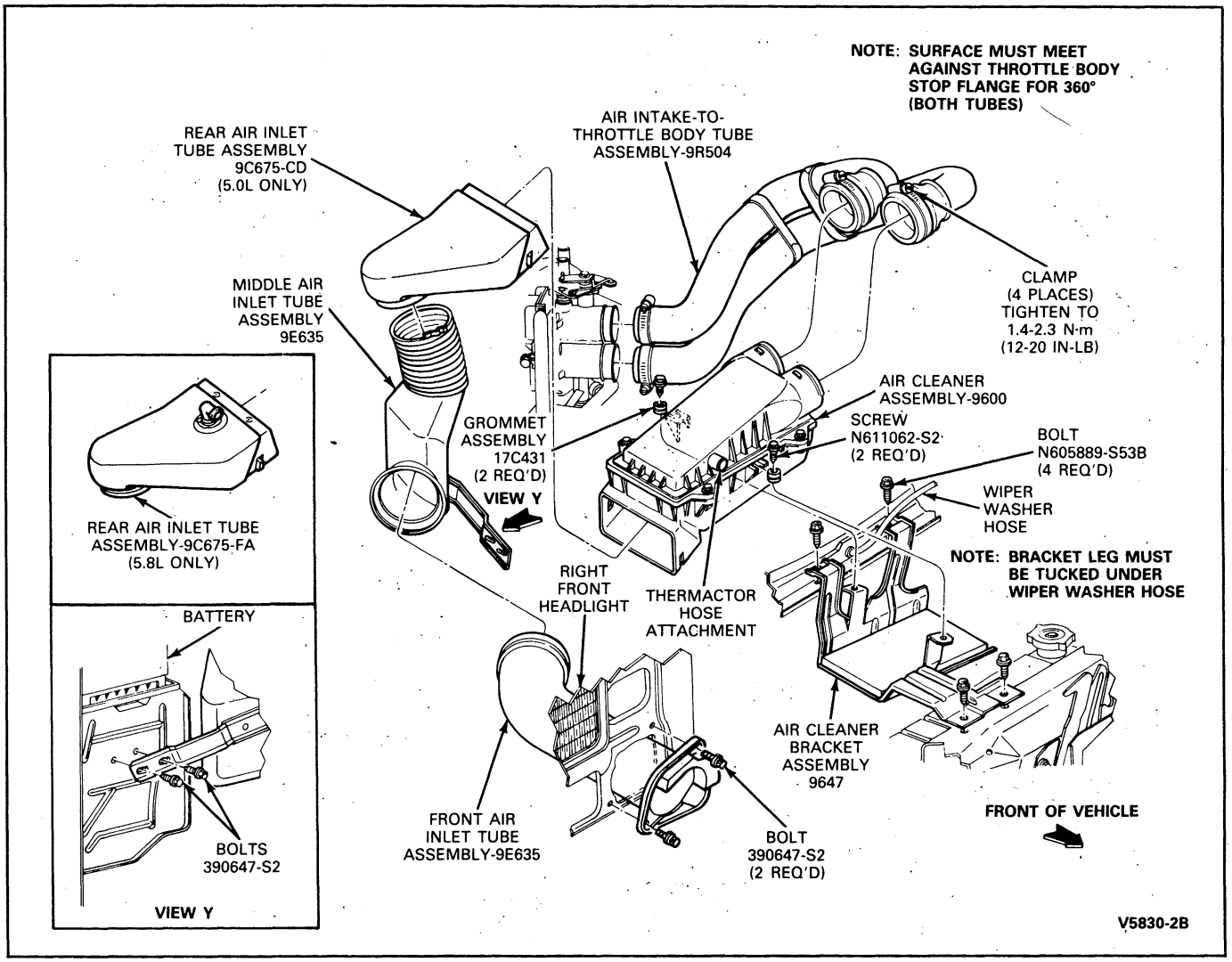


FIG. 6 Typical Air Cleaner Installation for E-150—E-350—5.0L/5.8LW EFI Engine

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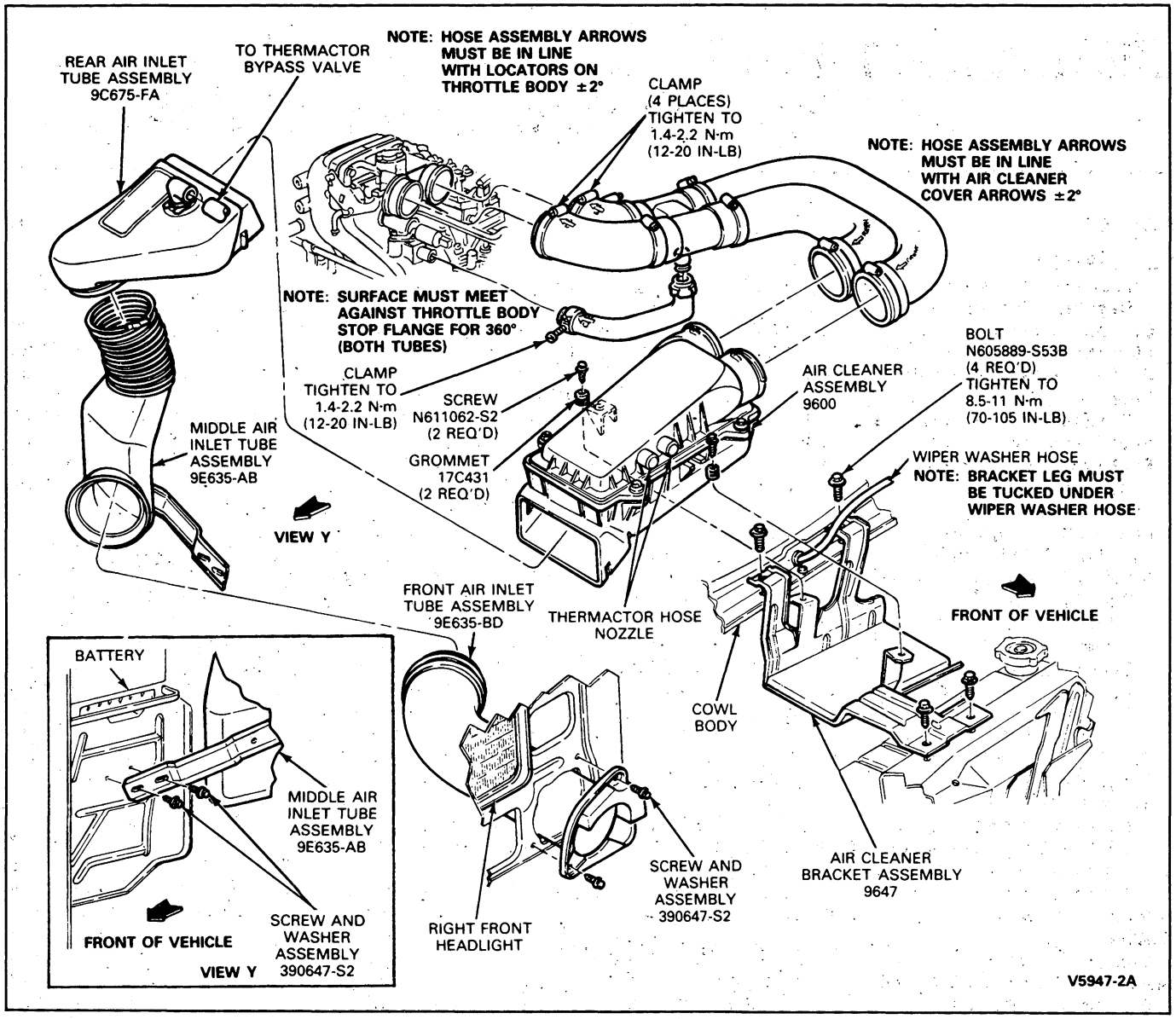


FIG. 7 Typical Air Cleaner Installation for E-Series—7.5L EFI Engine

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SECTION 24-50 Fuel Tanks and Lines and Fuel Evaporative Emission Control System

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VEHICLE APPLICATION

All Models with Gasoline Engines.

DESCRIPTION

Electronic Fuel Injection (EFI)

F-Series, Bronco and Econoline vehicles are equipped with EFI engines, which are fuel injected through an engine-mounted fuel rail to the intake port at each cylinder. The fuel systems which are used with fuel injected engines have electric fuel pumps to provide high pressure fuel to the injectors. A high-pressure pump and an in-line filter are located in the engine compartment and are attached to the LH side rail. A low-pressure pump is located in the fuel tank. The low-pressure in-tank fuel pump supplies fuel to the in-line reservoir, located to the rear of the transmission support, on the LH frame rail. The high-pressure pump then takes fuel from the reservoir and supplies it to the fuel injectors at each cylinder.

The fuel lines leading from the fuel tank to the engine are under pressure during vehicle operation. When fuel injected engines are turned off, the fuel in the fuel lines remains pressurized for long periods of time to provide quick start-ups. Special procedures for servicing these pressurized fuel systems are outlined.

Fuel Lines

Fuel lines are pressurized for electronically fuel injected engines. The nylon fuel tubes used on some engines are color coded blue for supply tubes and gray for return tubes for easy identification. The fuel lines, hoses and connections used with these various systems are as follows:

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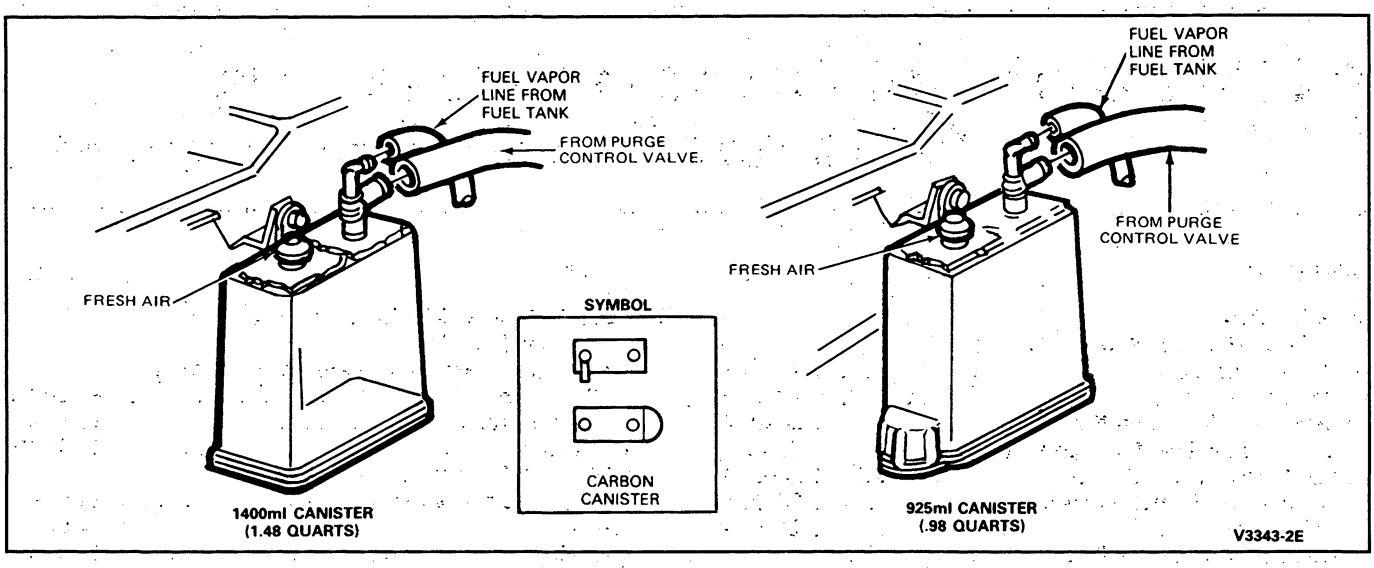


FIG. 1 Typical Canister

Pressurized Fuel Systems

Nylon and steel fuel tubes with push connect fittings are used on 4.9L, 5.0L, 5.8L and 7.5L EFI engines.

Fuel Evaporative Emission System

The evaporative emission system limits the amount of fuel vapor a vehicle may release to the atmosphere, enabling the vehicle to meet current federal and state requirements for fuel evaporation. The system works by capturing a very high percentage of fuel vapors that might otherwise escape from the gas tank. It then directs these vapors to the carbon canister where they are stored while the engine is not running. When the engine is running, and conditions are acceptable, the vapors are purged out of the canister and into the engine. This "clears" the canister and allows it to accept more fuel vapors the next time the engine is shut off.

The system is basically the same for all vehicle and engine lines: a hose or tube runs from the top of the fuel tank to the carbon canister to allow fuel vapors to pass from the tank to the carbon canister. A tube or hose runs from the carbon canister to the engine, allowing vapors to be purged from the canister. Some engines use additional valves in one or more of these lines to provide additional control over how much or when fuel vapor will be allowed to pass.

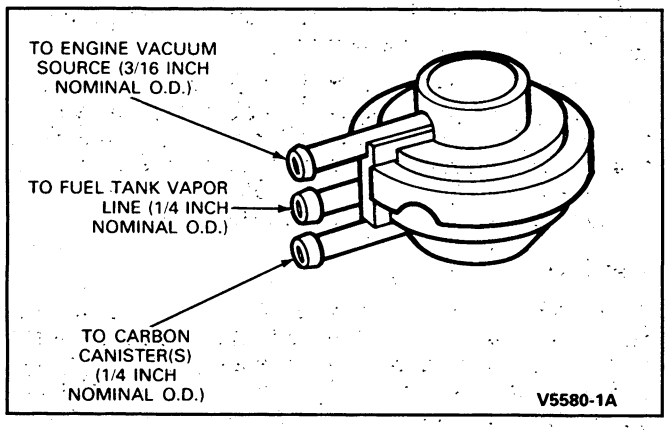


FIG. 2 Pressure Regulator Valve

The following are components of the evaporative emission system:

- Sealed Fuel Tank
- Pressure Vacuum Relief Fuel Cap
- Fuel Tank Vapor Valve
- Carbon Canister
- Purge Control Valve
- Canister Purge Solenoid or Purge Regulator Valve (Some Engines)
- Thermal Vent Valve (Some Engines)
- Vacuum Bowl Vent Valve (Some Engines)
- Vacuum Thermal Bowl Vent Valve (Some Engines)
- Solenoid Valve—Carburetor Bowl Vent
- Pressure Regulator Valve (Some Engines)
- Tank Vapor Valve—Orifice Rollover Valve

Carbon Canister

Typical carbon canisters are shown in Fig. 1. The carbon canister is normally mounted in or near the engine compartment. Two basic sizes are employed: 925ml or 1400ml. The "925" and "1400" refer to volume of activated carbon contained within the canister. Activated carbon is the working part of the carbon canister. It has the unique ability to absorb (store) and purge (remove) fuel vapors by passing fresh air through the carbon bed. It is able to do this over and over with almost no loss in ability to absorb and purge.

Thus, all sources of fuel vapor (fuel tank and carburetor fuel bowl) are routed to the carbon canister for absorption of fuel vapor.

Pressure Regulator Valve

The pressure regulator valve (Fig. 2) is installed on some E- and F-Series light trucks over 8500 GVW. The valve controls the amount of fuel vapor that will pass from the fuel tank(s) to the carbon canister(s). When the engine is off, the valve allows fuel vapors in the fuel tank(s) to build up to a certain pressure before allowing fuel vapors to pass from the fuel tank(s) to the carbon canister(s). Once the engine is started, engine vacuum will cause the valve to open and remain open while the

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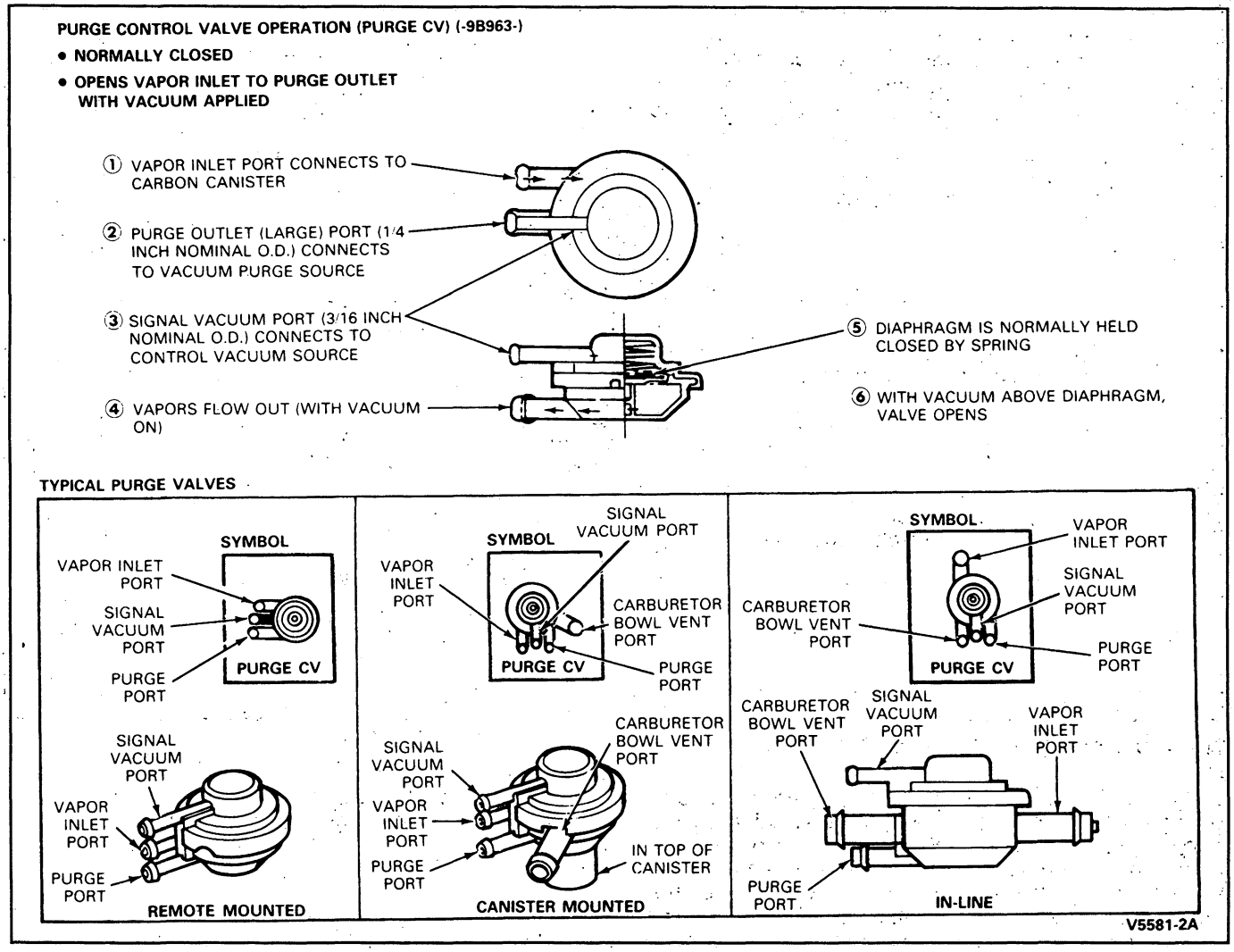


FIG. 3 Purge Control Valve

engine is running, allowing vapors to pass freely from the fuel tank(s) to the carbon canisters.

Purge Control Valve

The purge control valve is in line with the carbon canister and controls the flow of fuel vapors out of the canister. It is a normally closed valve that opens with vacuum input. Operation of the valve is shown in Fig. 3. Also shown in Fig. 3 are views of typical purge control valves.

Canister Purge Solenoid (Canister Purge Regulator Valve)

A typical canister purge solenoid is shown in Fig. 4. The canister purge solenoid is a normally closed valve. The valve is connected in line between the carburetor spacer nipple and the carburetor bowl vent hose.

The operation of the canister purge solenoid is controlled by the electronic control assembly (ECA) for vehicles with EEC-IV. When the engine is off, the canister purge solenoid is not energized and is in a closed, non-flowing condition. When the engine is running, the ECA reads engine RPM, engine load, engine temperature and other variables, and decides the proper time for the engine to accept fuel vapors. When this occurs, the ECA energizes the canister purge solenoid, allowing flow from the carbon canister to the intake manifold through the carburetor spacer. The vapors are then consumed in the engine. This action "purges" the carbon canister of fuel vapors. It occurs as fresh air is sucked into the carbon canister under the fresh air inlet cap of the canister and through the activated carbon bed. This allows the stored fuel vapors to pass from the canister through the fuel vapor return tube and the canister purge solenoid, and into the engine.

Thermal Vent Valve

The thermal vent valve (TVV) is a normally closed valve that opens when heated to 49°C (120°F) or higher.

The thermal vent valve (Fig. 5) is inserted in the carburetor-to-canister vent line and is closed when the engine compartment is cold. This prevents fuel tank vapors, generated when the fuel tank heats up before the engine compartment, from being vented through the carburetor fuel bowl.

This effect can occur, for instance, when sunlight strikes a vehicle which has been sitting out all night, and begins to warm the fuel tank. With the thermal vent valve closed, the vapors cannot enter the carburetor fuel bowl vent (now open) but must be routed to the

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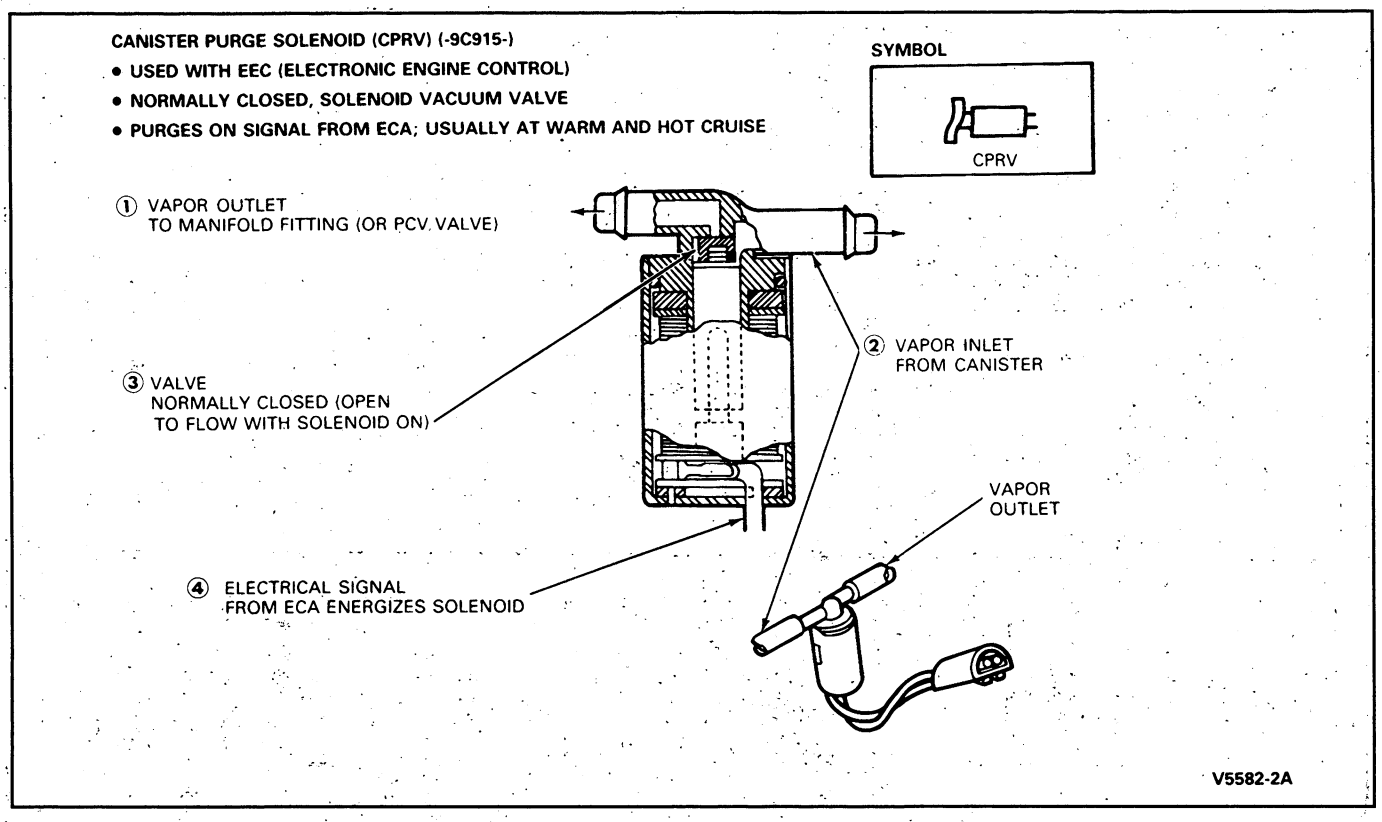


FIG. 4 Canister Purge Solenoid

carbon canister. As the engine compartment warms up, during normal engine operation, the thermal vent valve opens. When the engine is again turned off, the fuel bowl vent valve (or solenoid vent valve) opens, allowing vapors to flow through the thermal vent valve (now open) and into the carbon canister. As the thermal vent valve cools, it again closes and the cycle begins again.

Fill Control/Vent

Fill limiting is accomplished through fill pipe configuration and/or external vent lines within the fill pipe and tank. The vent system is designed to permit at least 10 percent tank volume air space when the tank is filled to capacity. This air space provides for thermal expansion of fuel as well as being an aid to the in-tank vapor vent system (Figs. 46 through 53).

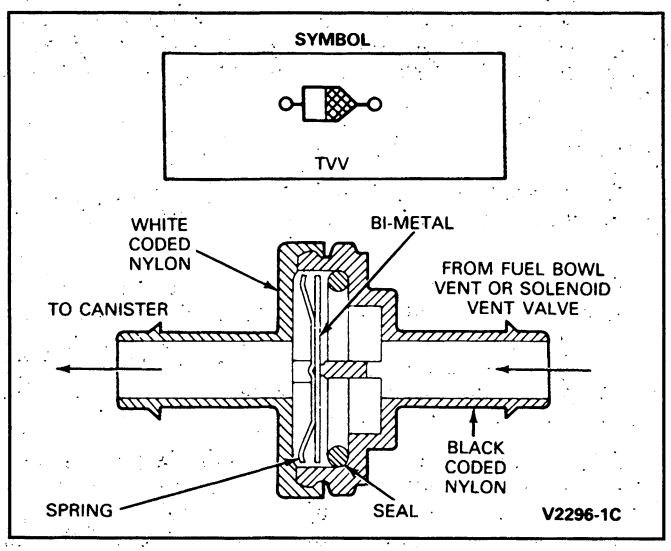


FIG. 5 Thermal Vent Valve

Vapor Vent

In-Tank Venting

This system provides a vapor space above the gasoline surface in the fuel tank. This area is sufficient to permit adequate breathing space for the tank vapor valve assembly under all static and most dynamic conditions. This is accomplished by a raised mounting section for the tank vapor valve assembly that is centrally located on the upper surface of the tank.

Tank Vapor Valve—Orifice Rollover Valve Assembly

All fuel tank vapor valves make use of a small orifice that tends to allow only vapor and not fuel to pass into the line running forward to the vapor storage canister. This assembly mounts directly to the fuel tank using a rubber seal (Fig. 16).

Fuel vapors trapped in the sealed fuel tank are vented through the orificed vapor valve assembly in the top of the tank. The vapors leave the valve assembly through a single vapor line and continue to the carbon canister for storage, until they are purged to the engine.

Mechanical Rollover Valve—3.8L EFI and 7.5L EFI Engine

The vapor valve assembly mounted on the top of the fuel tank is used to control the flow of fuel vapor entering the fuel tank vapor delivery line which conducts vapor forward to the canister in normal circumstances. If due to extreme conditions, excessive pressure is generated inside the tank, the purge port opens up, allowing fuel vapor to escape to the atmosphere, and

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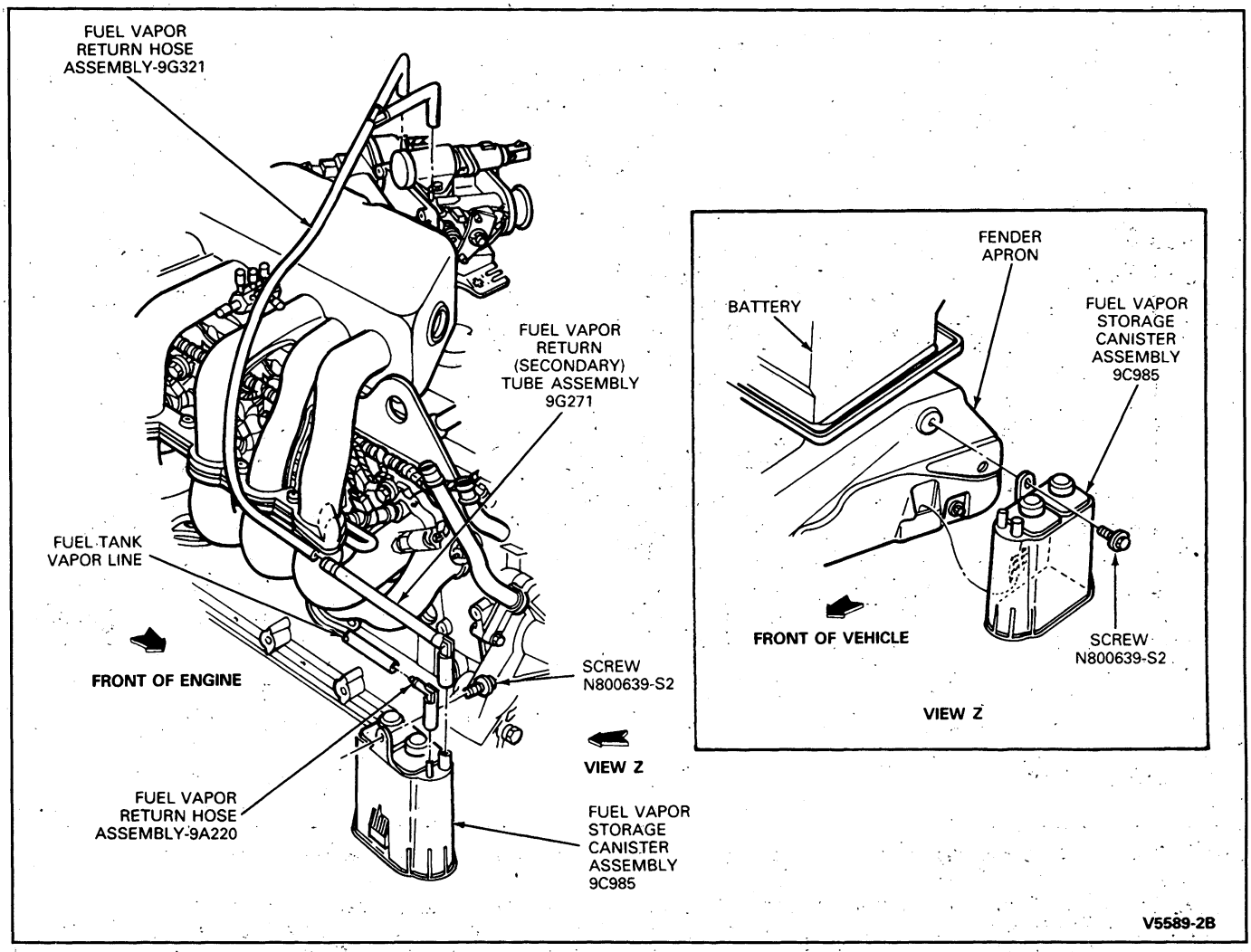


FIG. 6 Typical 4.9L EFI Evaporative Emission System—F-150—F-350 and Bronco

stabilizes pressure inside the tank. The valve assembly has a head valve which prevents the fuel tank from overfilling during refueling operation. The valve assembly also has a spring supported float assembly, which prevents liquid fuel from entering the vapor delivery line during severe handling, steep grades or in the event of vehicle rollover.

Thermactor Idle Vacuum Valve (TIV)

A Thermactor idle vacuum valve (TIV) is used with some evaporative emission systems to improve warm engine starting idle quality (Fig. 18).

When the engine is at normal operating temperature, the purge system is activated and purge air is drawn from the canister through the PCV tube and into the induction system through the carburetor spacer. The purge airflow into the carburetor spacer is taken into consideration when the idle air/fuel mixture is calibrated and set. However, under warm start conditions the purge valve is closed and the choke is off (no fast idle).

An overly rich mixture then exists, resulting in poor idle quality. The closed purge valve (choke off) no fast idle condition only exists for a few moments after a warm start, however, because actuation of the purge valve is delayed by the vacuum delay valve and by the time required to evacuate the vacuum reservoir.

To overcome this poor idle condition the TIV bleeds air into the PCV tube, leaning the idle fuel mixture until the purge valve opens. The same vacuum that opens the purge valve closes the TIV valve.

2-Port or 4-Port PVS—Ported Vacuum Switch

The PVS used in the evaporative system can be either a 2-port or a 4-port type. The 2-port type is the same as the EGR PVS, while the 4-port type is new and consists of two 2-port vacuum valves built into one body. The 4-port type performs the same function as two 2-port PVS valves. The PVS used in the evaporative emission control system turns the purge valve vacuum on as the engine warms up, and allows the purge valve to close when the engine is turned off and vacuum is lost (Figs. 19 and 20).

Pressure and Vacuum Relief System

Fuel Fill Cap

The fuel fill cap is sealed and includes a built-in pressure-vacuum relief valve. Fuel system vacuum relief is provided after 3.5 kPa (0.50 psi) and pressure relief after 11.0 kPa (1.6 psi). Under normal operating conditions, the fill cap operates as a check valve, allowing air to enter the tank as fuel is used, while preventing vapors from escaping the tank through the cap (Figs. 50 through 52).

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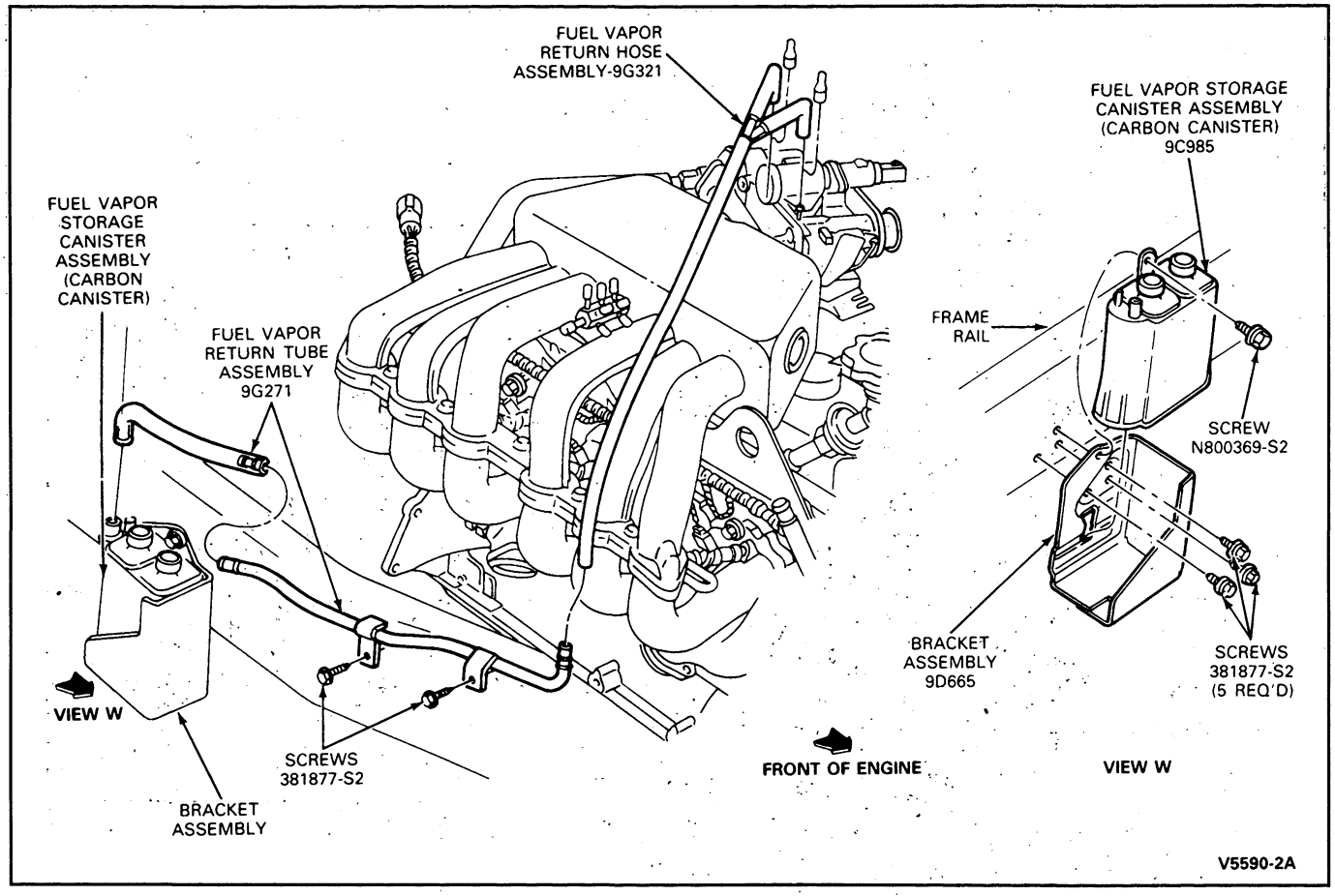


FIG. 7 Typical 4.9L EFI Evaporative Emission System—E-150—E-250 and Econoline, Under 8500 G.V.W.

NOTE: Use of an aftermarket fuel fill cap other than an authorized Ford/Motorcraft service part could result in damage to the fuel system or improper system operation if not properly designed/manufactured for pressure vacuum relief. Customer warranty is void for fuel tank and/or fuel system damage resulting from the use of such caps.

Fuel Line Routings

Figs. 31 through 48 show fuel line routings and tank installations.

Gasoline Octane Rating

Vehicles equipped with catalytic converters must use UNLEADED GASOLINE ONLY (as specified on the fuel gauge or adjacent to the fuel filler opening). Leaded gasoline can damage the catalytic converter and affects other emission components. When the engine is adjusted to recommended specifications, you may use a gasoline with a minimum octane rating as designated by any of the following numbers:

Research Octane Number (RON) ..91

Average of Research Octane Number and Motor Octane Number

(Antiknock Index).....87

Octane rating and unleaded gasoline availability may vary between gasoline stations.

Fuel Tank Filling

The filler tube openings for the fuel tanks on trucks with electronic fuel injection (EFI) engines have been made smaller to prevent accidental filling with other than unleaded fuel. Gasoline pumps in the United States and Canada dispensing unleaded fuel are equipped with nozzles to accommodate the smaller filler opening on the filler neck.

Expansion of fuel due to temperature increases, or overfilling ("topping off") causes fuel overflow at the filler cap when the vehicle is standing or the cap is removed. To minimize this condition, it is recommended that the amount of fuel put in the tank when filling be limited to the automatic pump shutoff. If vehicle has two tanks, use fuel from both tanks after fill-up to reduce fuel levels.

Fuel Tank Draining

Use appropriate adapter to connect Rotunda Fuel Storage Tanker 034-00002 or equivalent suction pump, to the fuel hose (at the fuel pump to fuel tube connection) and drain the fuel tank.

Fuel Selector Valve/Dual Function Reservoir

Refer to Fig. 22.

The 4.9L EFI, 5.0L EFI, 5.8L EFI or 7.5L EFI engine with dual tanks has three electric fuel pumps. Two low pressure in-tank fuel pumps, located in both the front and rear tanks, pump fuel into a reservoir. A high pressure in-line fuel pump then takes the fuel from the reservoir to the fuel injectors.

This system can draw fuel from either the front or rear fuel tank unit. With the ignition switch in START or RUN, current flows through a fuse link to the fuel pump relay.

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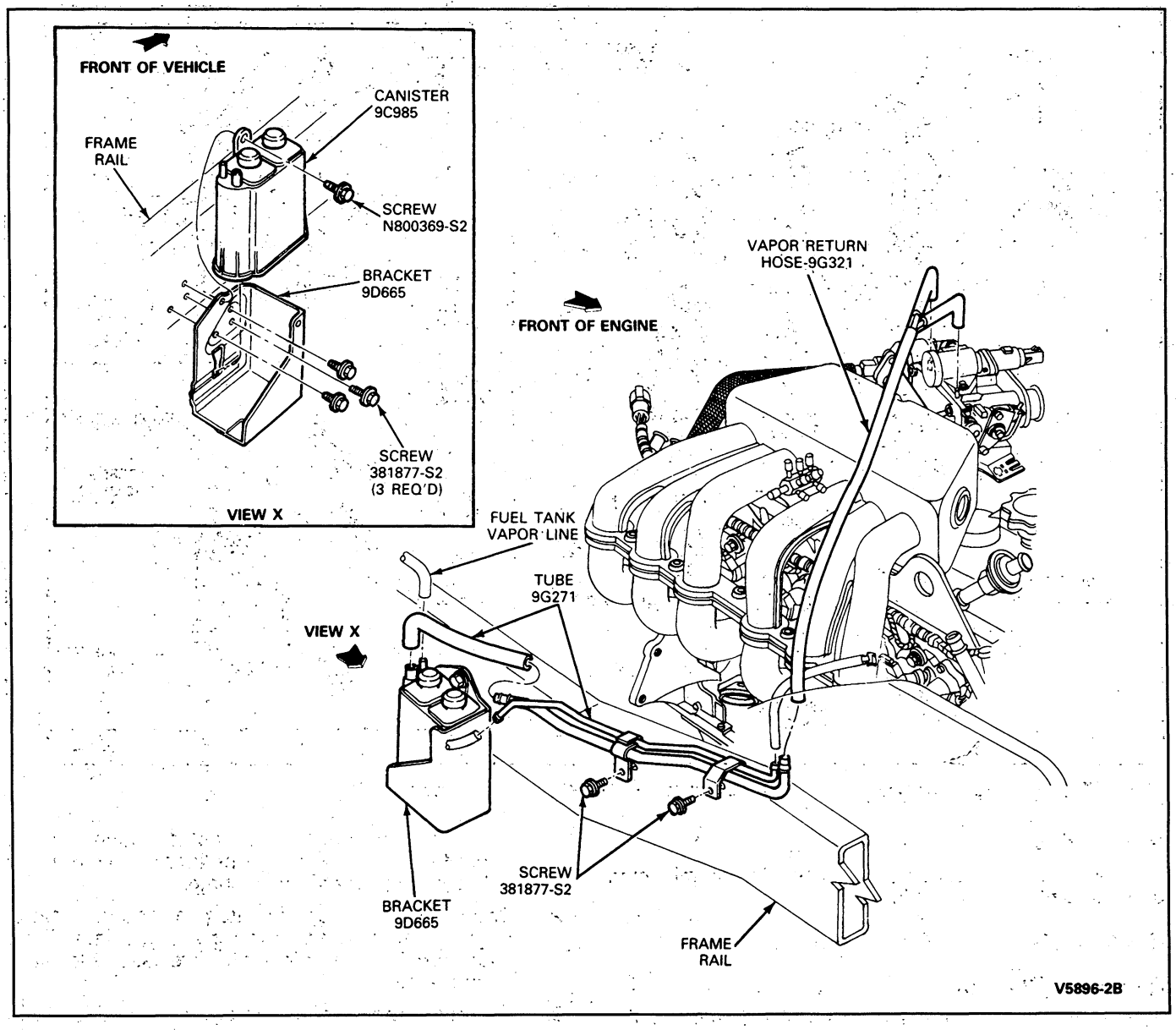


FIG. 8 Typical 4.9L Evaporative Emission System—E-250—E-350 and Econoline, Over 8500 G.V.W.

The dual function reservoir replaces the six port selector valve on fuel injected dual tank vehicles. The dual function reservoir switches the tank from which the engine draws fuel mechanically, instead of electrically.

The dual function reservoir operates as follows:

Fuel pressure created by the selected in-tank fuel pump exerts force on a 3 inch fluorosilicon diaphragm which is in turn connected to a T-bar and two shafts (Fig. 22). This force moves the valve shaft, simultaneously opening and closing the appropriate supply and return ports. When the alternate fuel tank is selected, pressure is exerted on the opposite side of the diaphragm, moving the valve shafts to open the alternate fuel tank ports.

Fuel Reservoir

The EFI engine with its fuel injectors has eliminated the requirement of the conventional carburetor bowl that is present on carbureted engines. One function that the carburetor bowl performed was to act as a fuel reservoir or fuel supply source for the engine when the in-tank fuel pick-up tube was exposed to the air during cornering or on steep grades under low fuel conditions. Any time the pick-up tube on an EFI engine without a fuel reservoir is exposed to the air, fuel starvation will occur.

To solve this, an in-line reservoir has been included in the fuel system. Under normal operating conditions, valving in the in-line reservoir allows the high-pressure pump and engine to be supplied with fuel directly from the tank while return flow is routed directly back to the tank. When the pick-up tube is exposed to air, the high pressure pump draws fuel from the reservoir. When the pick-up is again submerged, normal operation resumes.

There are two types of reservoirs—single function and dual function. A single function reservoir is used with single tank vehicles. The dual function reservoir is used with dual tank vehicles. A dual function reservoir combines the function of the reservoir with the function of a separate selector valve.

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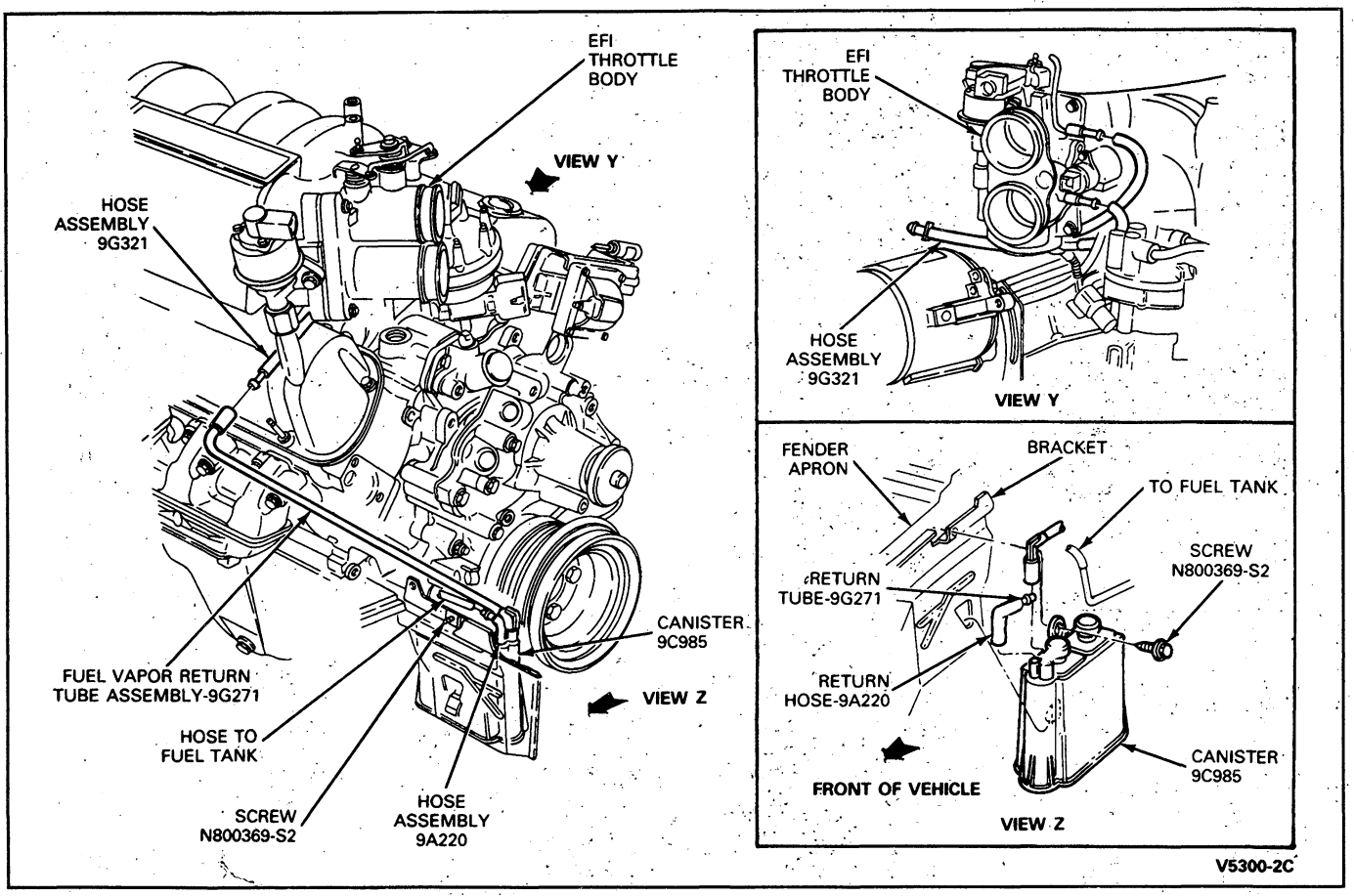


FIG. 9 Typical 5.0L Evaporative Emission System—F-150—F-250 and Bronco

Vapor Hoses

Vapor hoses should be assembled with the minimum engagement shown in Fig. 23.

DIAGNOSIS

Emission System

Physical damage, leaks, and missing items are the major answers to diagnosis of emission system complaints. Fill cap damage or contamination that renders the pressure-vacuum valve inoperative may result in deformation of the tank. Care should always be exercised to ensure a proper fill cap (in working order) is used. Typical carbon canister systems are shown in Figs. 6 through 15.

Refer to Volume H, Section 3 of the Engine/Emission Diagnosis* manual for individual components.

REMOVAL AND INSTALLATION

Fuel System Pressure Relief

EFI Engines

CAUTION: Fuel supply lines on 4.9L EFI, 5.0L EFI, 5.8L EFI, and 7.5L EFI engines will remain pressurized for some period of time after the engine is shut off. This pressure must be relieved before servicing of the fuel system.

Before opening the fuel system on vehicles with EFI engines, relieve fuel pressure as follows:

1. Locate and disconnect the electrical connection to either the fuel pump relay, the inertia switch or the in-line high pressure fuel pump.
2. Crank engine for approximately ten seconds. Note: Engine may start and run for a short time. If so, crank engine an additional five seconds after engine stalls.
3. Connect the electrical connector that was disconnected in Step 1.
4. Disconnect battery ground cable.

Fuel Lines and Hoses

CAUTION: Fuel supply lines on vehicles with fuel injected engines will remain pressurized for long periods of time after engine shut-down. The pressure must be relieved, as outlined, before servicing the fuel system.

Push Connect Fittings

Push connect fittings are designed with two different retaining clips. The fittings used to connect to 9.5mm (3/8-inch) and 7.9mm (5/16-inch) nominal diameter tubing use a "hairpin" clip (Fig. 24). The fittings used with 6.3mm (1/4-inch) nominal diameter tubing uses a "duck bill" clip (Fig. 24). Each type of fitting requires different procedures for service. Clips should be replaced whenever a connector is removed.

The fuel lines connecting to the EFI engine fuel rails are a special, spring-lock, metal design. The fuel feed line uses a 12.7mm (1/2-inch) spring lock connector.

*Can be purchased as a separate item.

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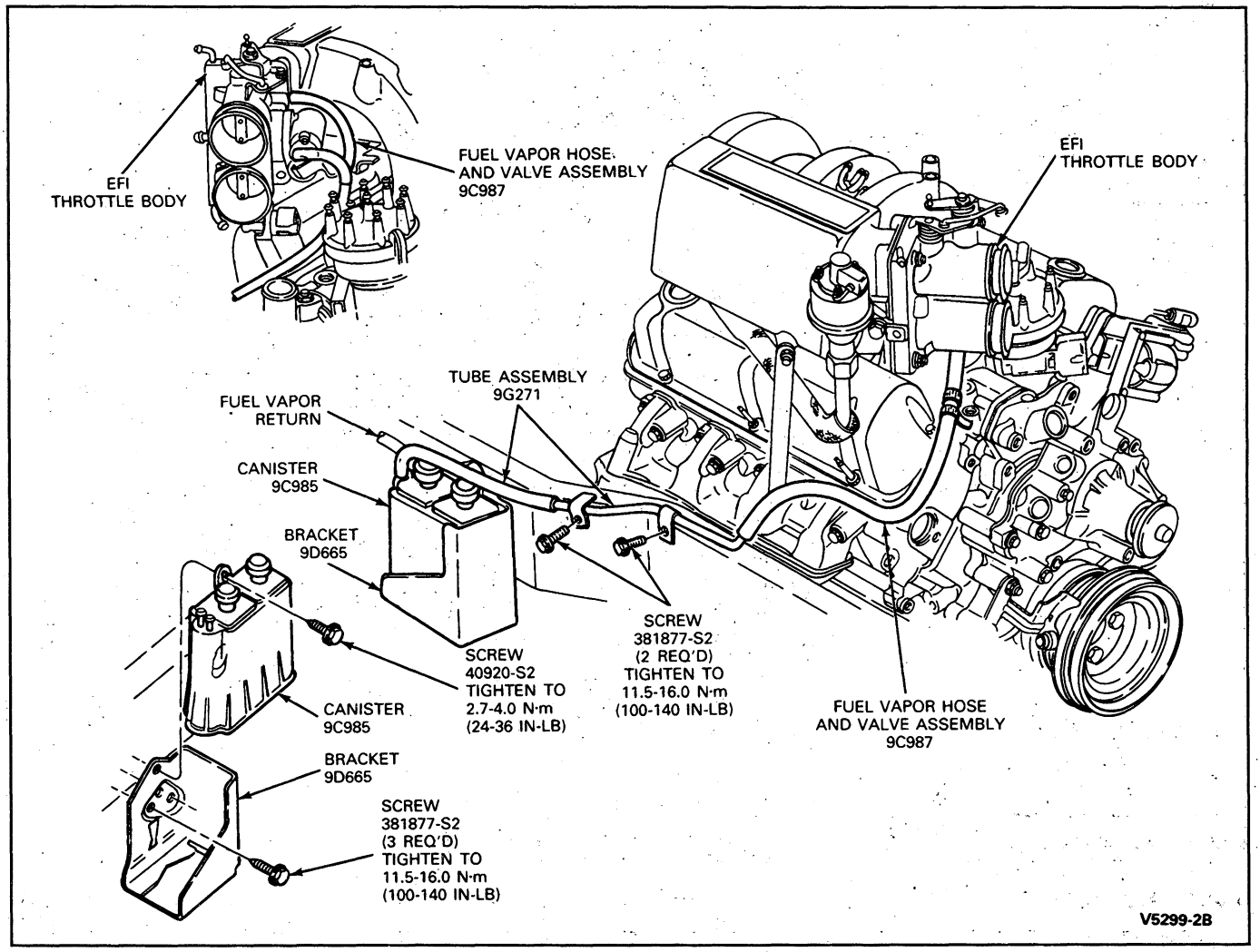


FIG. 10 Typical 5.0L Evaporative Emission System—E-150—E-350

The fuel return uses a 9.5mm (3/8-inch) spring lock connector.

Disconnect all push connect fittings from components (pump, filter, engine) prior to component removal. The push connect fittings to connect flexible fuel lines to the fuel tank sender often cannot be disconnected until the tank is partially lowered just before removing the fuel tank completely.

7.9mm (5/16-Inch) or 9.5mm (3/8-Inch) Fittings (Hairpin Clip)

Removal

1. Inspect visible internal portion of fitting for dirt accumulation. If more than a light coating of dust is present, clean the fitting before disassembly.
2. Some adhesion between the seals in the fitting and the tubing will occur with time. To separate, twist the fitting on the tube, then push and pull the fitting until it moves freely on the tube.
3. Remove "hairpin" type clip from fitting by first bending the shipping tab downward so that it will clear the body. Next **(using hands only)**, spread the two clip legs approximately 3mm (1/8 inch) each to disengage the body and push the legs into the fitting. Complete removal is accomplished by **lightly** pulling from the triangular end of the clip and working it clear of the tube and fitting.

   CAUTION: Do not use any tools.
4. Grasp the fitting and hose assembly and pull in an axial direction to remove the fitting from the tube.
5. When fitting is removed from the tube end, inspect the fitting and tube for any internal parts that may have been dislodged from the fitting. Any loose internal parts should be immediately reinstalled, using the mating tube to insert the parts.

Installation

1. It is recommended that the original clip **not** be reused in the fitting. To install the new clip, insert clip into any two adjacent openings with the triangular portion pointing away from the fitting opening. Install clip to fully engage the body (legs of "hairpin" clip locked on outside of body). Piloting with an index finger is necessary.
2. Before installing fitting on the tube, wipe tube end with a clean cloth. Inspect the inside of the fitting to ensure it is free of dirt and/or obstructions.
3. To install the fitting onto the tube, align the fitting and tube axially and push the fitting onto the tube end (Fig. 25). When the fitting is engaged, a

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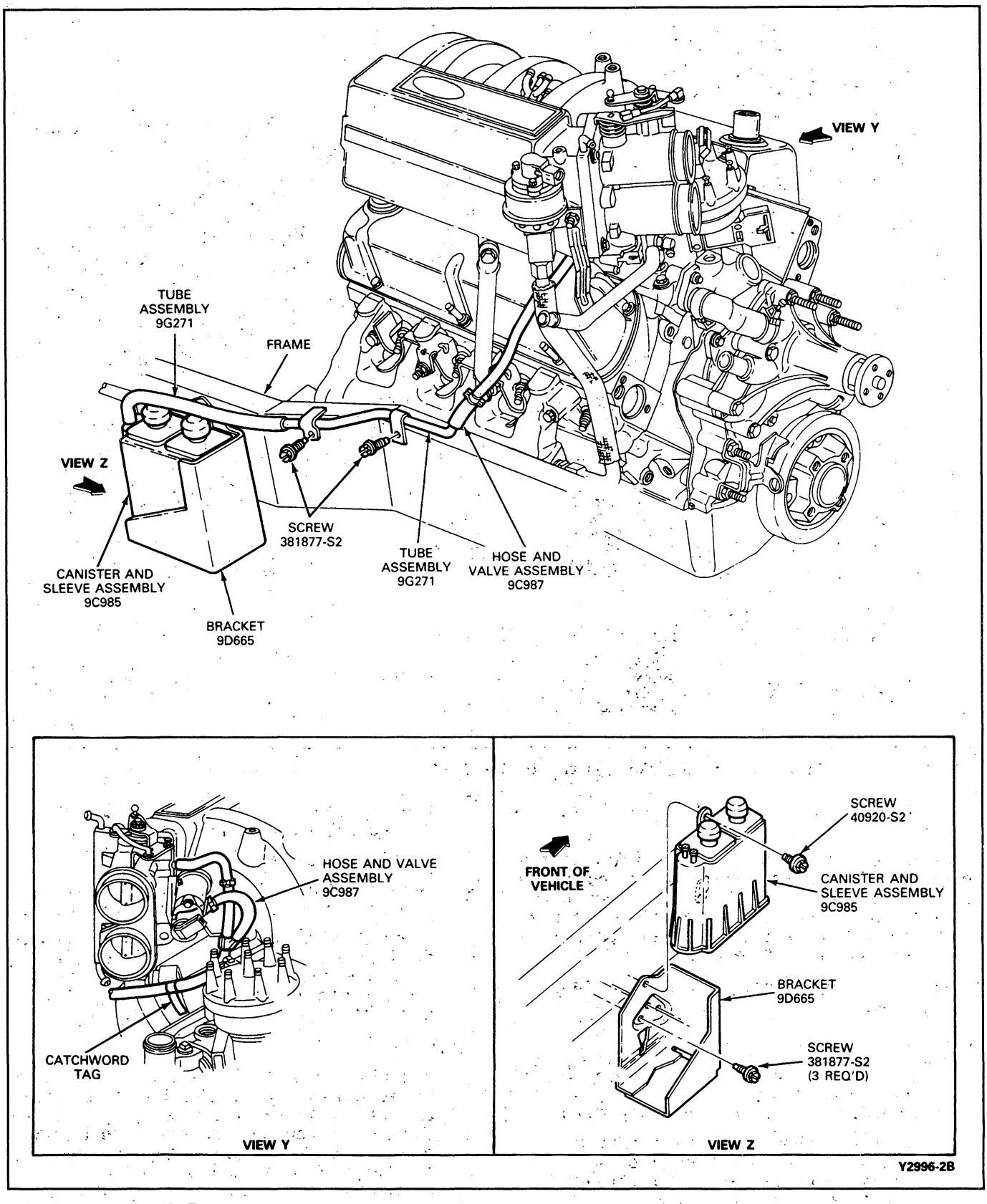


FIG. 11 Typical 5.8L Evaporative Emission System

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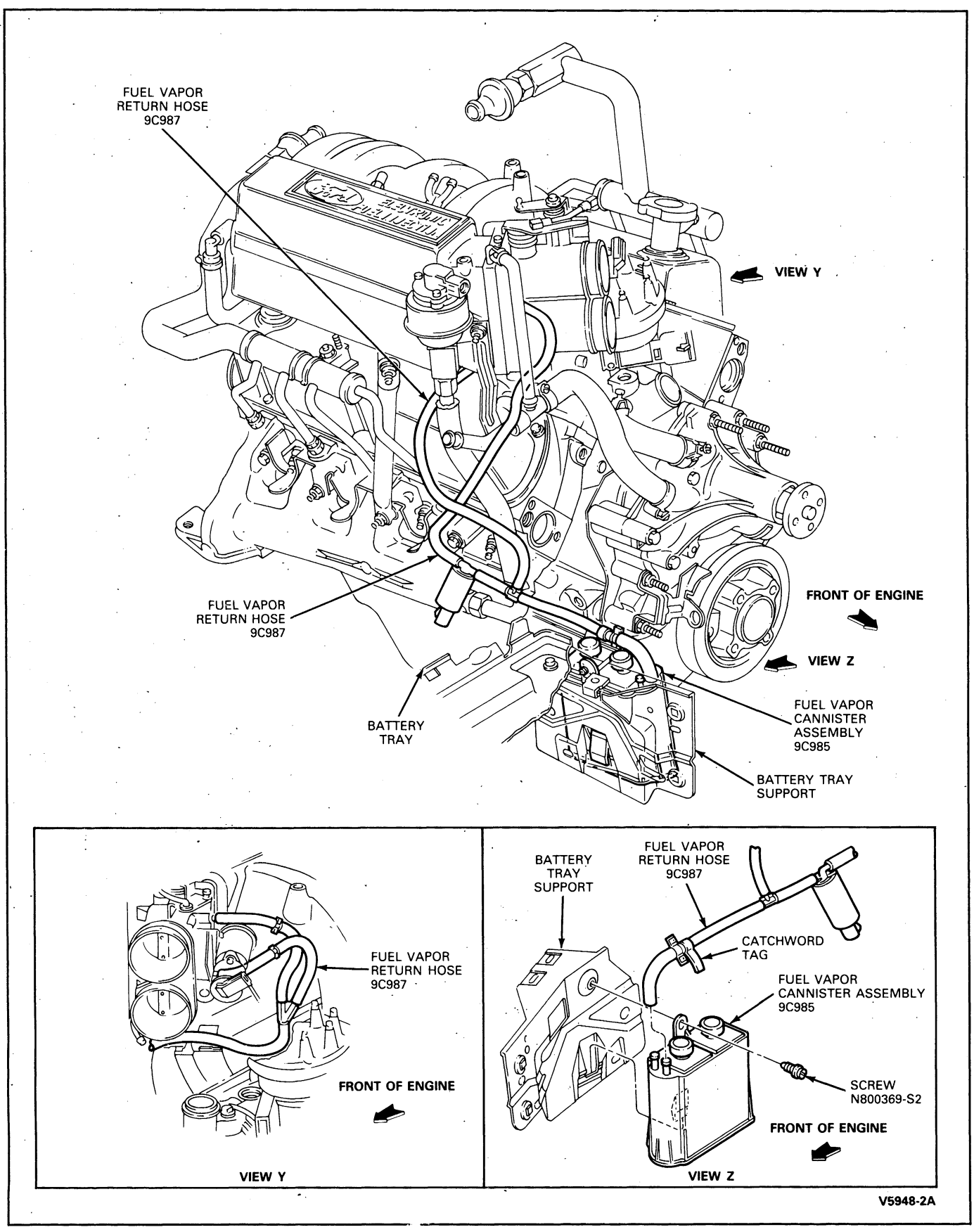


FIG. 12 Typical 5.8L EFI Evaporative Emission System—F-250, F-350

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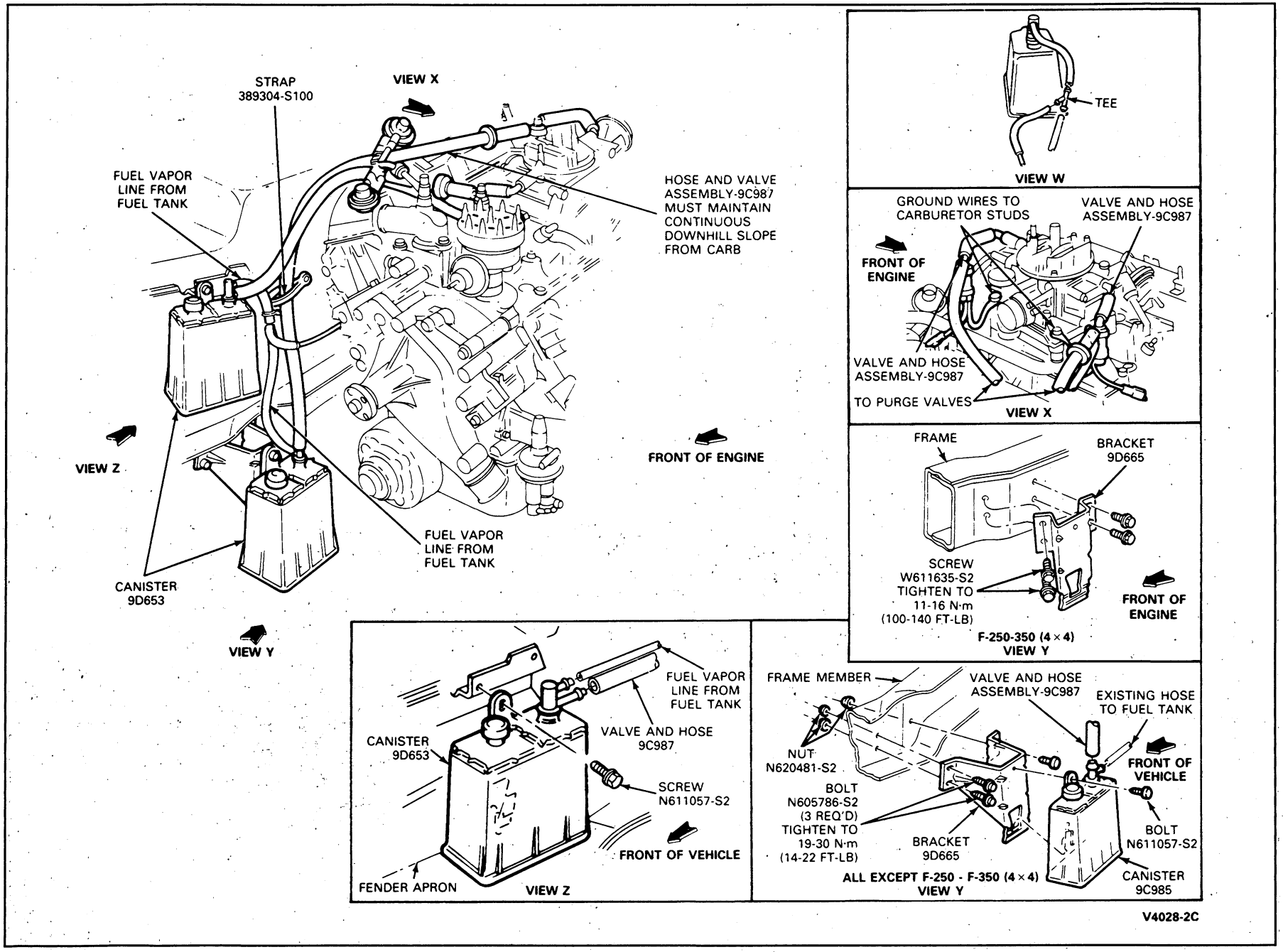


FIG. 13 Typical 7.5L Evaporative Emission System—California—F-250—F-350

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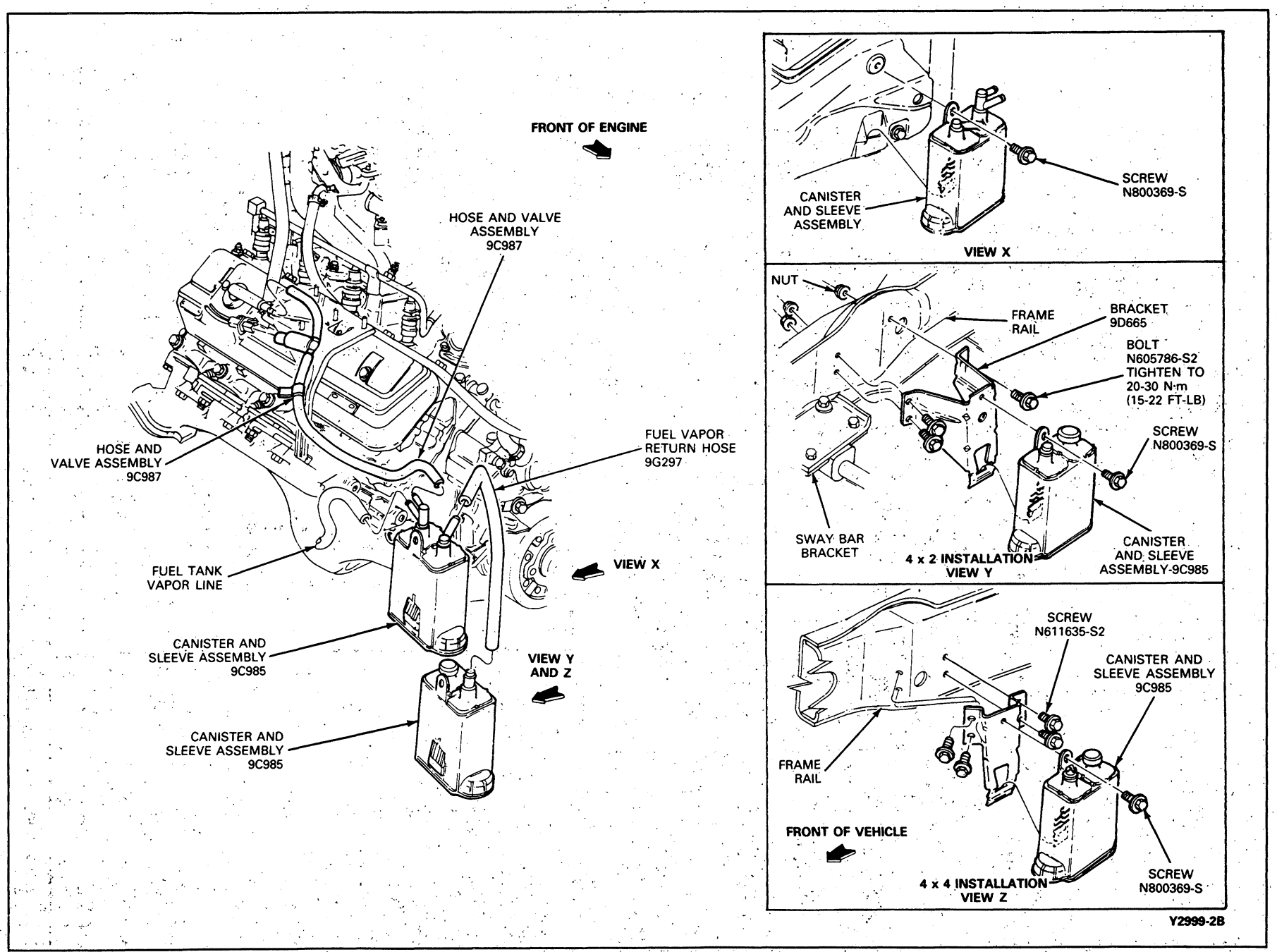


FIG. 14 Typical 7.5L Evaporative Emission System—50 States and Canada — F-250, F-350 (over 8500 GVW)

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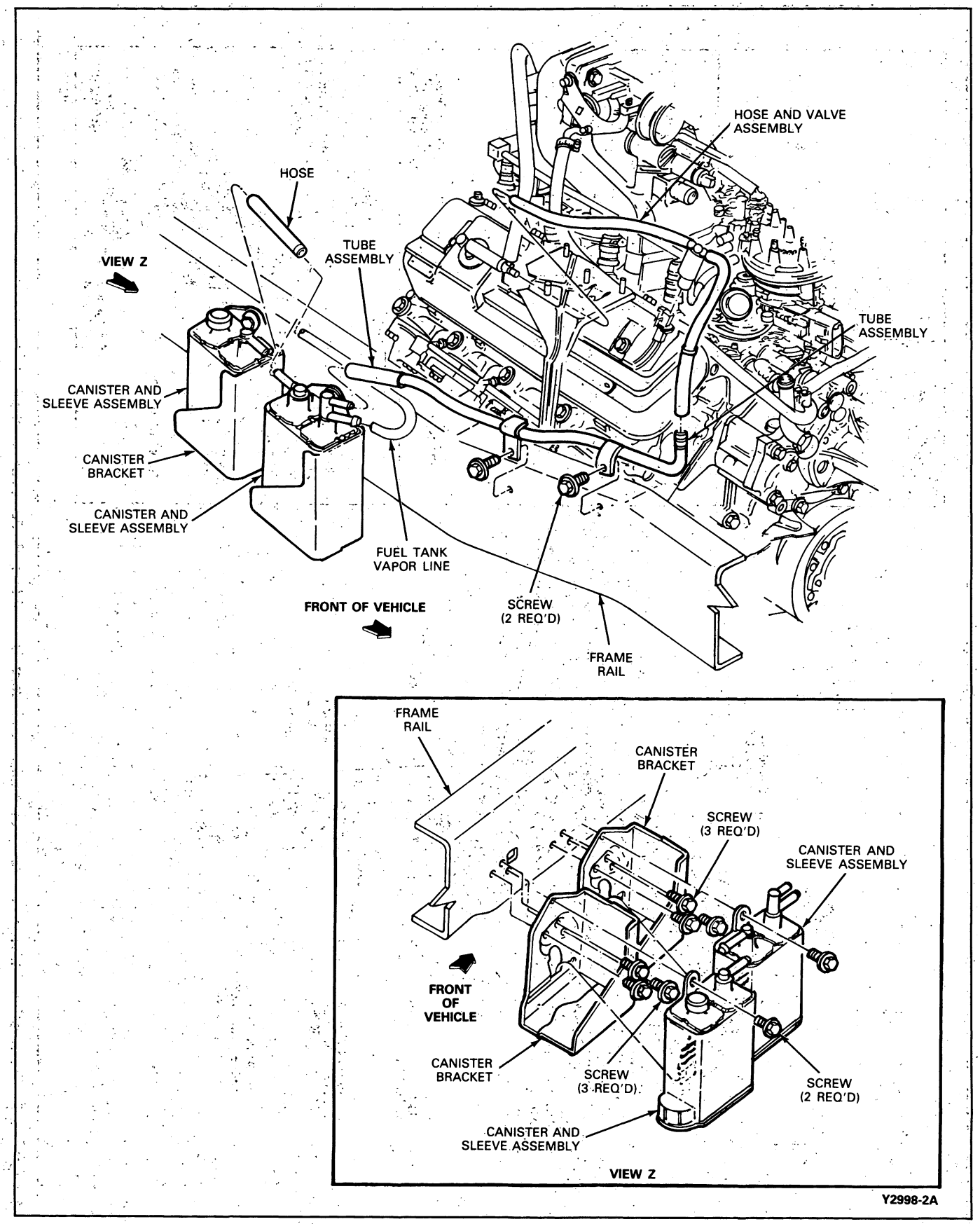


FIG. 15 Typical 7.5L Evaporative Emission System—50 States—E250—E350 (over 8500 GVW)

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definite click will be heard. Pull on fitting to ensure it is fully engaged.

Metal Spring-Lock Connectors (4.9L EFI, 5.0L EFI, 5.8L EFI and 7.5L EFI Engines)

The tools in Fig. 26 will not always fit over the shielded line. To accommodate the shielding, the hole in the tubing end of the tool must be enlarged. To do this, clamp the tool closed and drill out the existing hole with 5/8-inch bit. Be careful to drill only the tubing hole and not the working end of the hole.

Fuel Tubes—Plastic

CAUTION: Ford-approved nylon fuel tubing is made from material which has been tested and proven to be acceptable for use with commercially available fuels. It is also resistant to most environmental conditions. Avoid using alternate tubing materials. Use of non-approved tubing could pose a hazard in service.

CAUTION: Plastic fuel tube must not be repaired using hose and hose clamps. Push connect fittings cannot be repaired except to replace the retaining clips. Should the plastic tubes, push connect fittings, or steel tube ends become damaged and leak, approved service parts (Fig. 28) must be used to service the fuel lines.

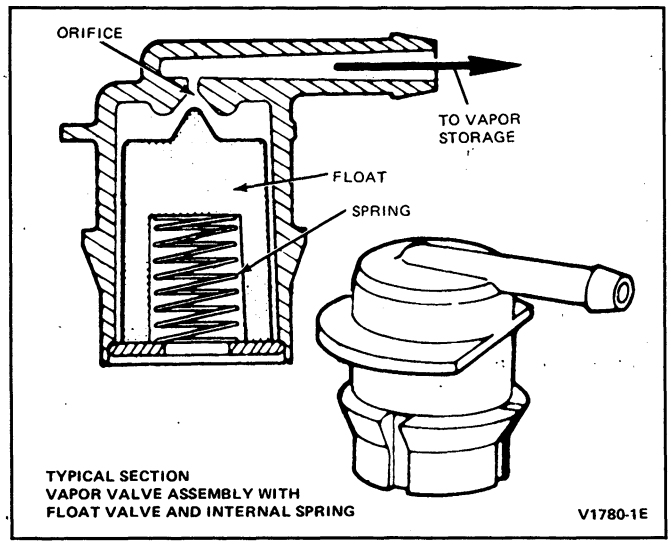


FIG. 16 Fuel Tank Vapor Valve

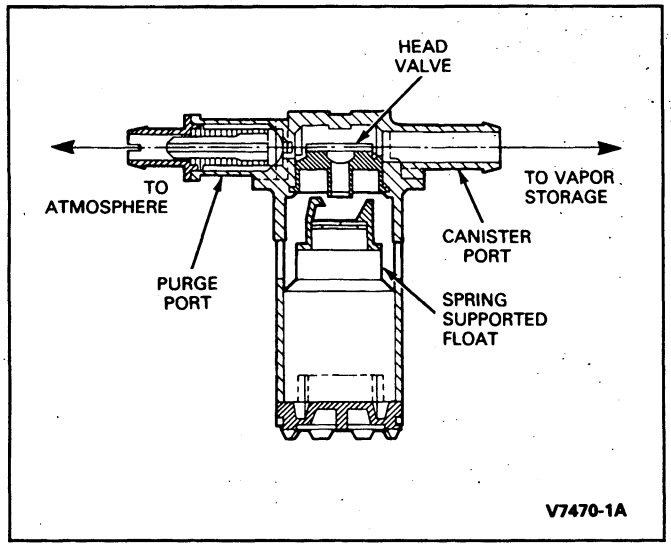


FIG. 17 Mechanical Rollover Valve—5.8L EFI and 7.5L EFI

The F-Series, Econoline and Bronco vehicles use at least some flexible nylon fuel and fuel return lines. The plastic fuel tube assembly is secured to the body rails with nylon wrap-around clips and push-in clips.

CAUTION: The plastic fuel lines can be damaged by torches, welding sparks, grinding, and other operations which involve heat and high temperatures. If any repair or service operation will be used which involves heat and high temperatures, locate all fuel system components, especially the plastic fuel lines, to be certain they will not be damaged. It is recommended that the plastic fuel tubes be removed from the vehicle if a torch or high heat producing equipment is to be used for service in the following areas:

1. Exhaust or suspension components in proximity to fuel tubes.
2. Underbody frames, rails and crossmembers (LH side).
3. Dash panel; under vehicle or inside the passenger compartment (lower LH side).
4. Front or rear wheel house/fender apron (LH side).

Fuel Return System

A fuel return system is used to maintain fuel flow at the fuel charging assembly.

The fuel return system is serviced in the same manner as the fuel lines.

NOTE: Plastic fuel return tubes must be repaired using the repair procedure for plastic tubes.

NOTE: Torque specifications are included in applicable illustrations.

Fuel Filter

Refer to Section 24-51, Fuel Filters, for fuel filter removal and installation procedures.

Fuel Reservoir—Econoline

NOTE: The removal of the Econoline transmission crossmember on the 138 inch wheelbase vehicles requires that the fuel reservoir be removed first. If the reservoir is not removed before removal and/or installation of the transmission crossmember, interference will occur and damage to the reservoir may occur. Removal of the reservoir is not required for removal of the E4OD transmission crossmember.

Removal

1. Disconnect the fuel lines from the fuel reservoir (single or dual function).
2. Remove the four bolts which hold the reservoir bracket to the frame.

Installation

1. Install the fuel reservoir and bracket assembly. Tighten the four attaching bolts to 17-23 N·m (12-17 ft-lbs.).
2. Prepare the push connect fittings on the disconnected fuel lines for installation and install the fuel lines as outlined.

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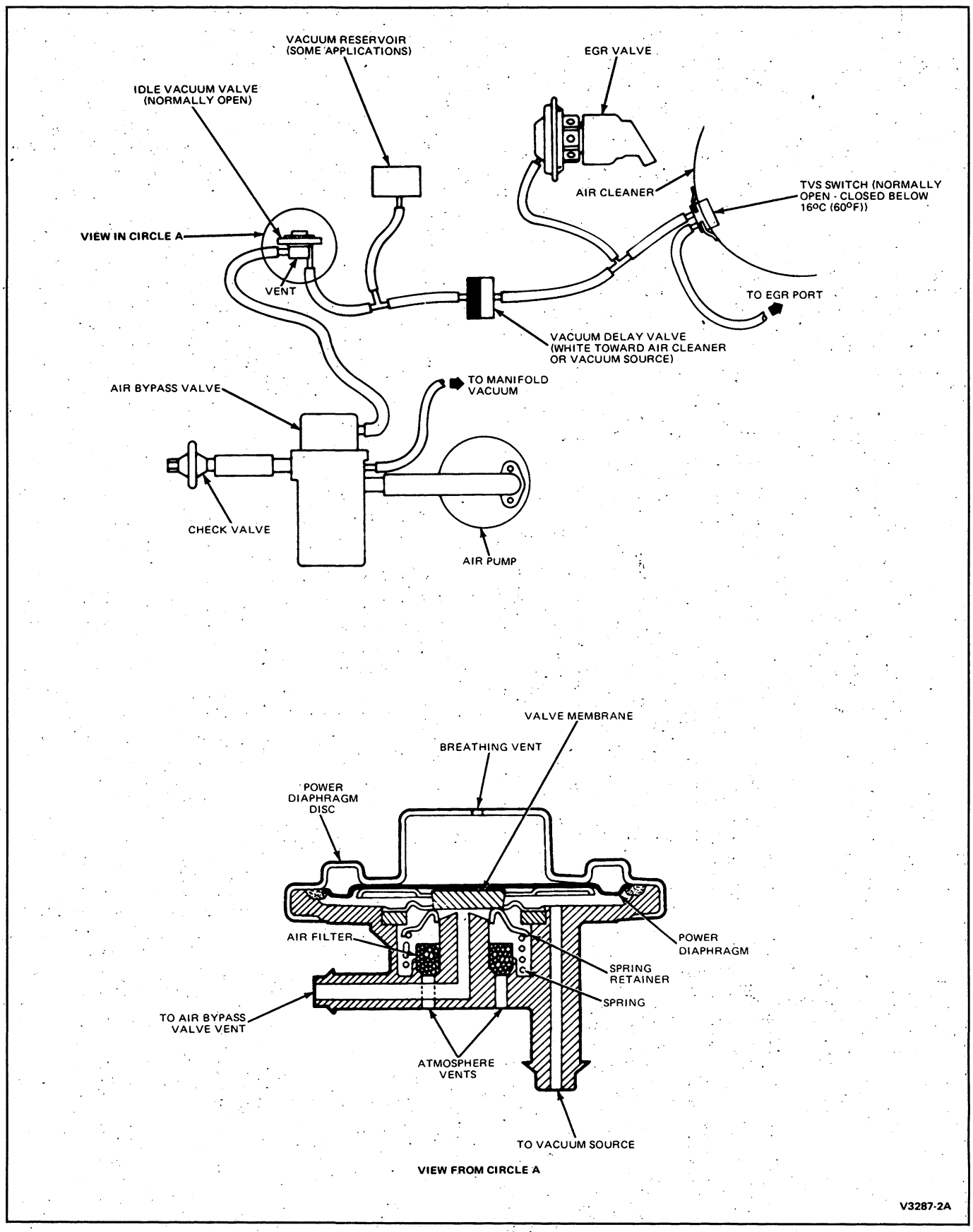


FIG. 18 Thermactor Idle Vacuum Valve (TIV)

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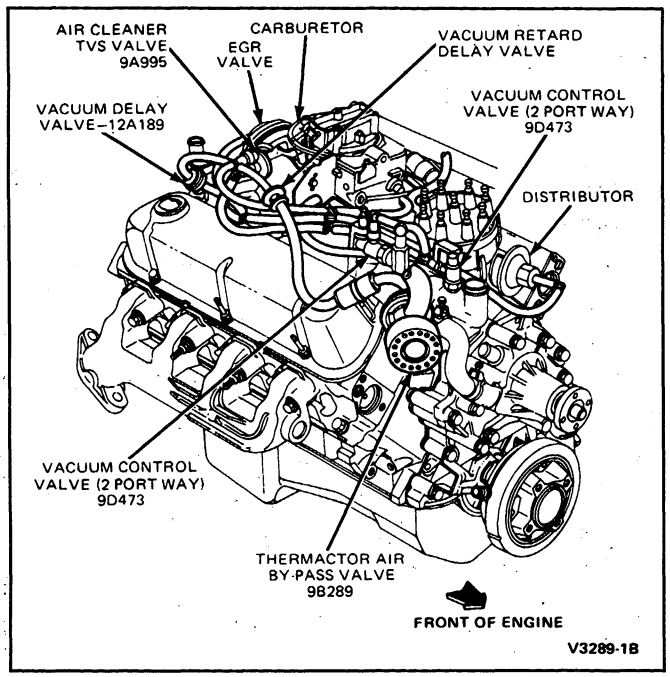


FIG. 19 Port Vacuum Switch—Typical

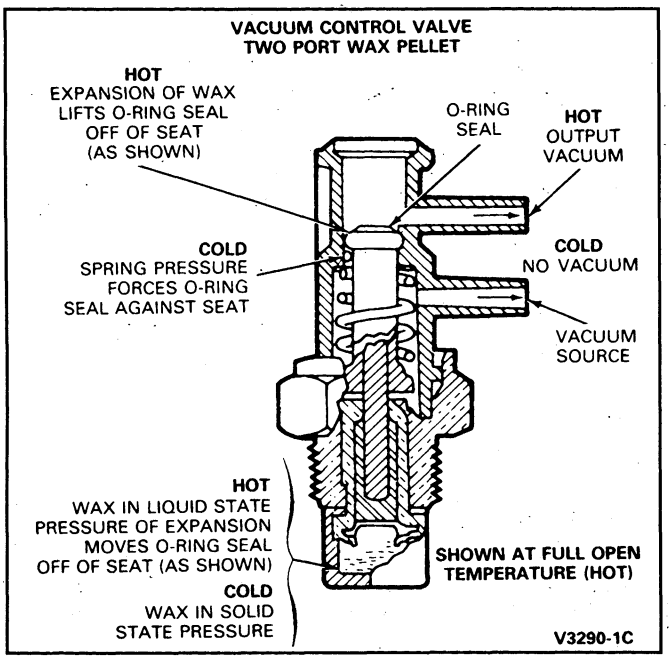


FIG. 20 Two Port and Four Port Vacuum Control Valves

Fuel Tanks

F-150—F-350, F-Super Duty Chassis Cab and Motor Home Chassis

Typical fuel line and tank installations are shown in Figs. 32 through 40. Refer to the specifications for the capacities and usage.

Midship Fuel Tank — Plastic

Refer to Fig. 21.

Removal

1. Drain the fuel into a suitable container by siphoning through the fuel hose at the fuel pump-to-fuel tube connection.
2. To avoid electrical sparking at the tank, disconnect the ground cables on both batteries.
3. Remove skid plate and heat shields.
4. Disconnect the fuel gauge sending unit wire at the fuel tank.
5. Loosen fuel filler hose clamp at the tank and disconnect the fuel filler hose.
6. Disconnect the fuel tube push-connect fittings at fuel gauge sending unit.
7. Support the tank. Remove the bolts from the retaining straps and lower the tank to the floor.
8. To remove fuel gauge sending unit, rotate threaded retainer ring counterclockwise with TOOL (TBI) or equivalent.
9. To remove vapor valve, pull it out of the grommet.
10. Replace any worn or damaged parts.

Installation

1. Position fuel gauge sending unit seal in groove. Then, position fuel gauge sending unit in tank and install threaded retainer ring with TOOL (TBD) or equivalent. Tighten to 55-68 N·m (40.6-50.1 ft-lb).
2. Insert vapor valve into grommet.
3. Position tank in vehicle and secure retaining straps to frame with hand-started attaching bolts.
4. Position and secure fuel filler hose on fuel tank filler neck. Tighten hose clamp to 3-4 N·m (27-35 in-lb).
5. Clip vapor valve hose to frame rail.
6. Connect the fuel tubes and electrical connector to the fuel gauge sender unit.
7. Tighten strap attaching bolts to 16-24 N·m (11.8-17.7 ft-lb).
8. Position heat shield on fuel tank retaining strap studs and tighten attaching nuts to 8-11 N·m (5.9-8.1 ft-lb).
9. Position skid plate in vehicle and secure the skid plate and heat shield to frame with attaching bolts and nuts. Tighten to 8-11 N·m (5.9-8.1 ft-lb).
10. Position heat shield in vehicle and secure it to the frame and the heat shield with attaching bolts. Tighten to 8-11 N·m (5.9-8.1 ft-lb).
11. Connect battery ground cables at both batteries.
12. Fill the tank and check all connections for leaks.

Midship Fuel Tank Steel

Refer to Figs. 37 and 38.

Removal

1. Drain the fuel into a suitable container by siphoning through the fuel hose at the fuel pump-to-fuel tube connection.
2. To avoid electrical sparking at the tank, disconnect battery ground cable. Then disconnect the fuel gauge sending unit wires at the fuel tank.
3. On vehicles with dual tanks, disconnect ground wire after draining both tanks. Loosen the clamp

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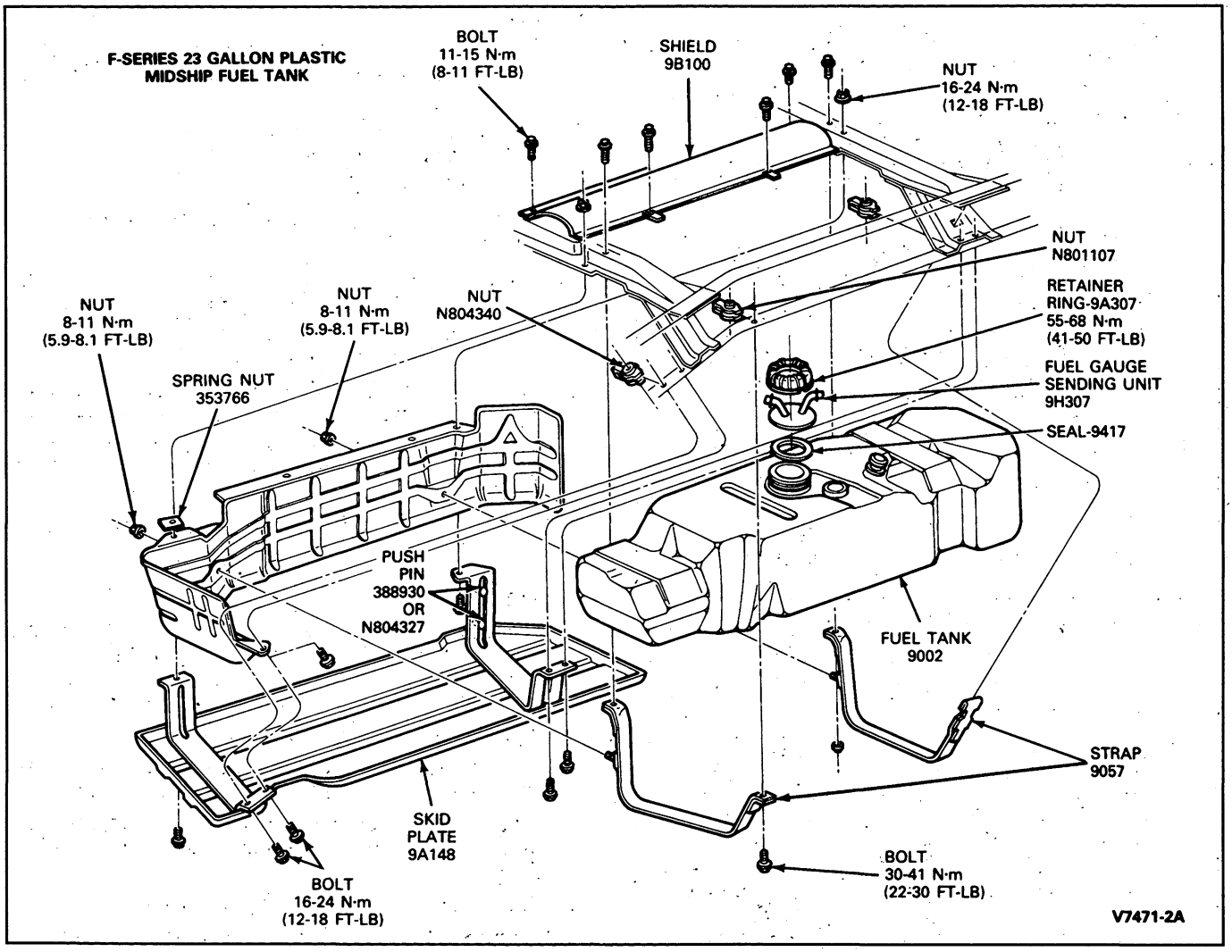


FIG. 21 F-Series 23 Gallon Plastic Midship Fuel Tank

and disconnect the hose attached to the fuel tank by pulling along the rubber inner tube from the tank filler neck. On a vehicle equipped with a fuel evaporative emission control system, disconnect the vapor line from the vapor emission control valve.

4. Support the tank, remove the nuts and bolts from the retaining straps, and lower tank to floor. Replace any worn or damaged parts.

Installation

1. Position retaining straps around fuel tank and attach bolts and nuts. Tighten to 30-41 N·m (22-30 ft-lb).
2. Insert the rubber inner tube inside the filler neck and connect the hose to the tank. Tighten the clamps to 3-4 N·m (25-35 in-lb). On a vehicle equipped with a fuel evaporative emission control system, connect the vapor lines to the emission control valve located in the top of the vapor tank.
3. Fill tank with fuel, connect the battery ground cable, and start the engine. Check for leaks.

Aft-Of-Axle Fuel Tank

Refer to Figs. 31, 32, 35, 36, 39 and 40.

Removal

1. Raise the rear of the vehicle.
2. To avoid electrical sparking at the tank, disconnect battery ground cable. Then disconnect the fuel gauge sending unit wire at the fuel tank.
3. On vehicles with dual tanks disconnect the ground wire after both tanks have been drained. Siphon the fuel from the tank into a suitable container at the hose between the fuel pump and the fuel tube.
4. Loosen the fuel line hose clamps, slide the clamps forward and disconnect the fuel line at the fuel gauge sending unit.
5. If the fuel gauge sending unit is to be removed, turn the unit retaining ring counterclockwise and remove the sending unit, retaining ring and gasket.
6. Loosen the clamp on the fuel filler pipe. Disconnect the filler pipe hose by pulling along the rubber inner tube from the tank filler neck.
7. If removing the metal-type tank, support the tank and remove the bolts attaching the tank supports to the frame. Carefully lower the tank and disconnect the vent tube from the vapor emission control valve in the top of the tank. Finish removing the filler pipe and filler pipe vent hose if not

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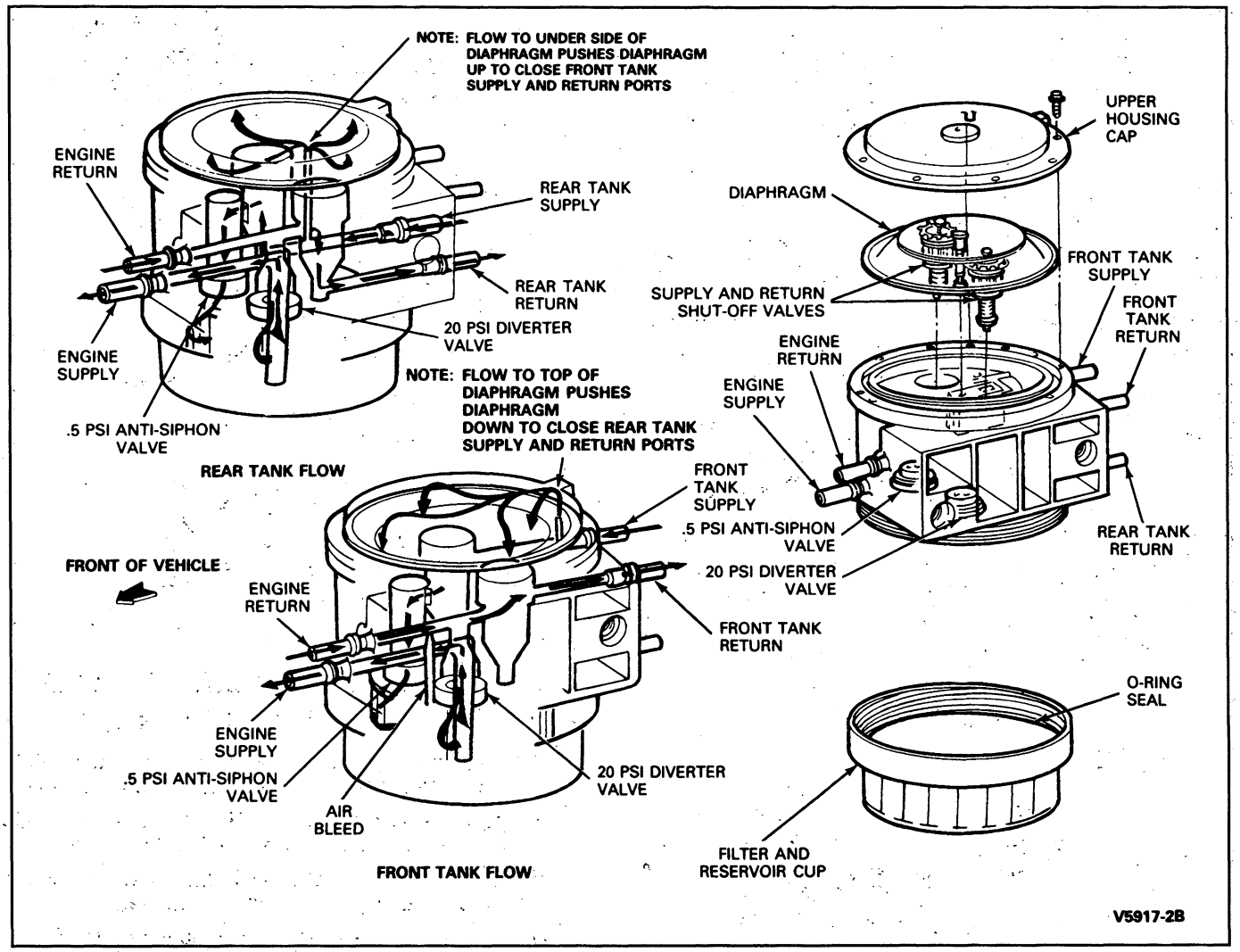


FIG. 22 Dual Function Reservoir—F/E Series Schematic

possible in Step 6. Remove the tank from under the vehicle.

8. If removing the plastic-type tank, support the tank and remove the bolts attaching the combination skid plate and tank support to the frame. Carefully lower the tank and disconnect the vent tube from the vapor emission control valve in the top of the tank. Complete removing the filler pipe if not possible in Step 6. Remove the skid plate and tank from under the vehicle. Disassemble the skid plate from the tank.

Installation

1. If the tank or vapor emission control valve is being replaced, follow the installation procedures in Figs. 6 through 15. Install new support strap insulation as required.
2. If installing the plastic-type tank, assemble the skid plate and support straps to the tank (Fig. 36).
3. Raise the tank skid plate and support assembly and attach the vent hose to the vapor emission control valve.
4. Start the tank neck into the hose.
5. Position the tank assembly against the top straps or the frame. Install the attaching bolts and nuts using thread adhesive (such as Locktite). Tighten the attaching bolts and nuts to 37-50 N·m (27-37 ft-lb).

   NOTE: The plastic tank attaching bolts and nuts do not utilize thread adhesive. Tighten these bolts and nuts to 34-47 N·m (25-35 ft-lb).
6. Insert the rubber inner tube inside the tank filler neck and connect the filler pipe hose. Tighten the clamps to 3-4 N·m (25-35 in-lb).
7. If the fuel gauge sending unit was removed, ensure all the old gasket material has been removed from the unit mounting surface on the tank. Using a new gasket, position the fuel gauge sending unit to the fuel tank and secure with the retaining ring.
8. Connect the fuel gauge sending unit wire to the sending unit.
9. Connect the fuel line at the fuel gauge sending unit and tighten the clamps securely. Install the drain plug, if so equipped.
10. Connect the vehicle battery ground cable removed in Removal Step 2.
11. Fill the tank and check all connections for leaks.
12. Lower the vehicle.

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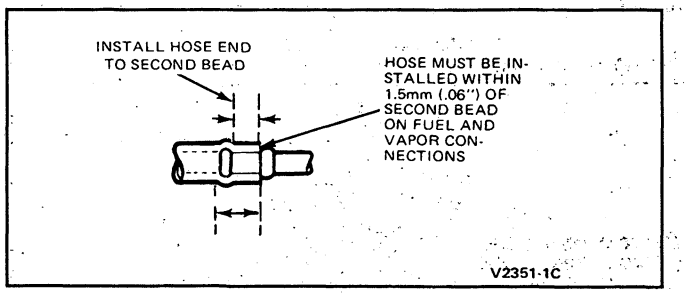


FIG. 23 Fuel and Vapor Hose Connections

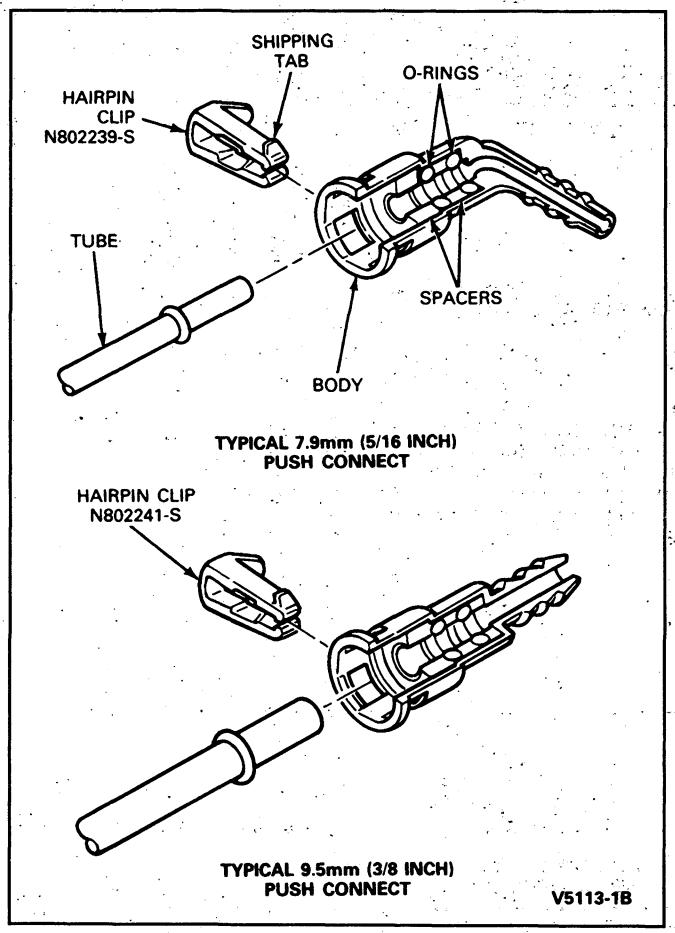


FIG. 24 Typical Push Connect Fittings

E-150—E-350

The E-150—E-350 fuel line fuel tank installations are shown in Figs. 41 through 48.

Aft Axle Body-Mounted Tanks

Removal

1. Drain the fuel into a suitable container by siphoning through the fuel line at the fuel reservoir connection.
2. Raise the rear of the vehicle.
3. To avoid electrical sparking at the tank, disconnect the ground cable on the vehicle battery. Then disconnect the fuel gauge sending unit wires at the fuel tank.
4. Loosen the clamps on the fuel filler hose and vent hose at the tank neck. Disconnect the hoses from the tank.

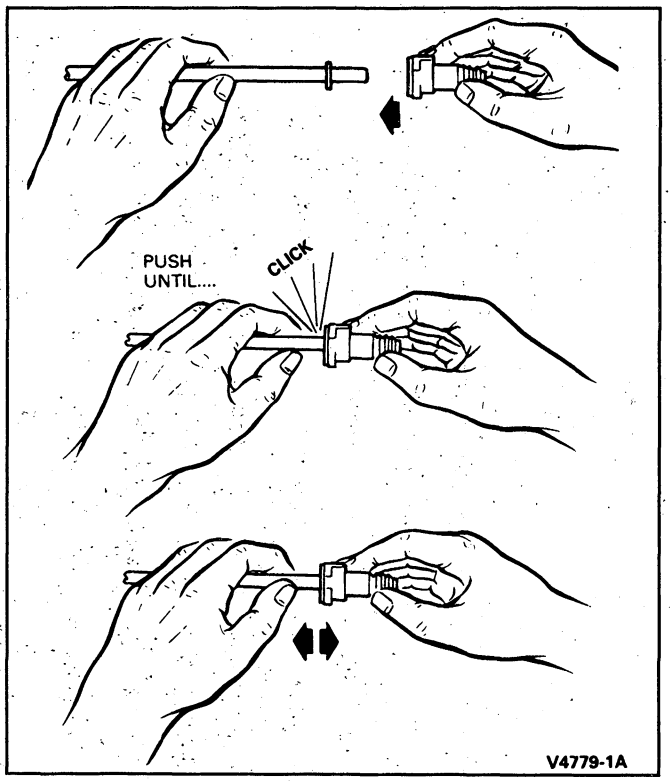


FIG. 25 Connecting "Push Connect" Fittings

5. Remove the fuel line hairpin clips and disconnect the fuel lines from the fuel gauge sending unit.
6. Support the tank in position. Remove the nuts that attach the mounting straps to the "T" bolts.

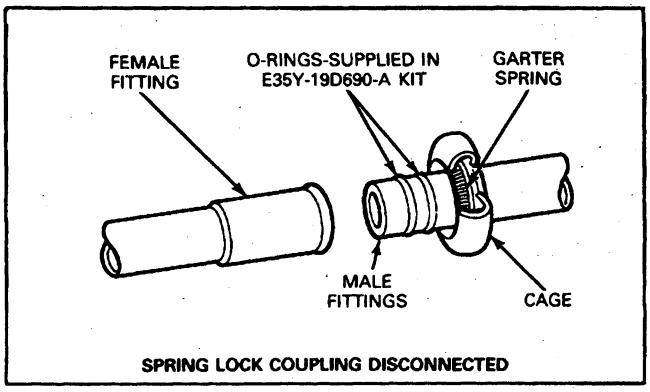
   NOTE: The "T" bolts are attached to body brackets located at the rear of the tank.

   Disengage the straps from the T-bolts and the front body brackets. Lower the tank enough to gain access to the vapor valve.
7. Disconnect the carbon canister hose from the vapor control valve.
8. Lower the fuel tank and remove it from underneath the vehicle.
9. If the fuel gauge sending unit is to be removed, turn the unit retaining ring counterclockwise and remove the sending unit retaining ring and gasket.
10. If the vapor control valve is to be removed, pull it out of the grommet located in the top of the tank and remove the grommet.

Installation

1. If the fuel gauge sending unit was removed, scrape away the old gasket material from the unit mounting surface on the fuel tank. Using a new gasket, position the fuel gauge sending unit to the fuel tank and secure with the retaining ring.
2. If the vapor control valve was removed, install the grommet in the tank opening and press-fit the valve into place.
3. Attach the front ends of the mounting straps to the front body brackets.
4. Raise the tank high enough to connect the carbon canister hose to the vapor valve. Connect the hose.

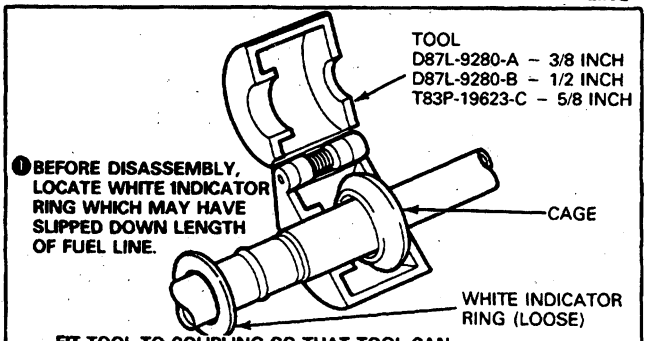
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SPRING LOCK COUPLING DISCONNECTED

TO DISCONNECT COUPLING

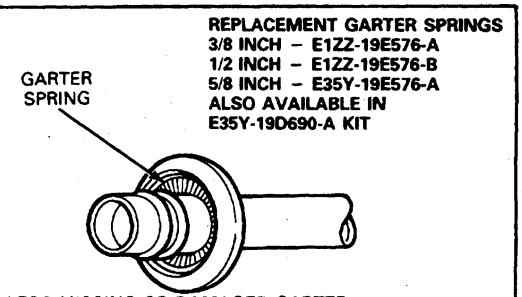
CAUTION – DISCHARGE SYSTEM BEFORE DISCONNECTING COUPLING



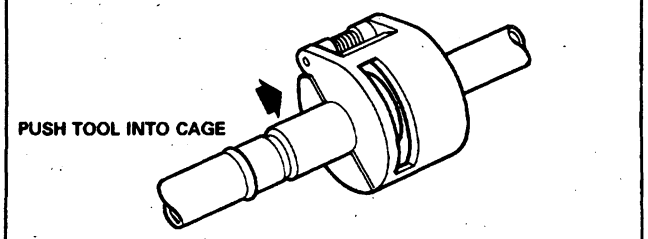
1 BEFORE DISASSEMBLY, LOCATE WHITE INDICATOR RING WHICH MAY HAVE SLIPPED DOWN LENGTH OF FUEL LINE.

2 FIT TOOL TO COUPLING SO THAT TOOL CAN ENTER CAGE TO RELEASE THE GARTER SPRING.

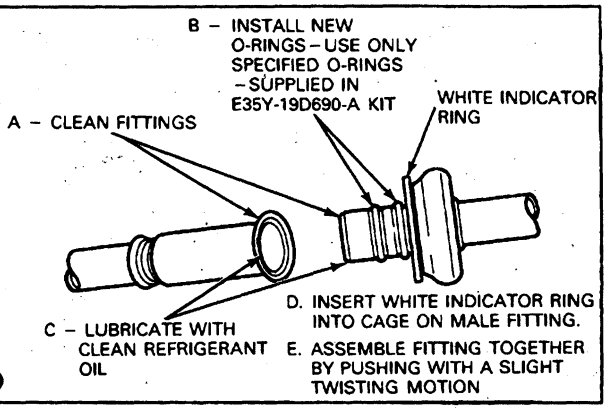
TO CONNECT COUPLING



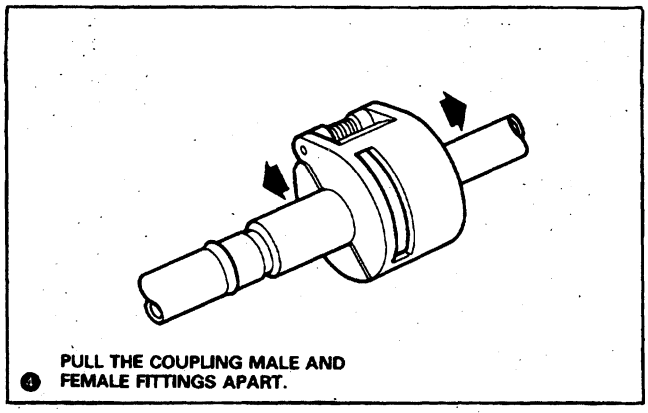
1 CHECK FOR MISSING OR DAMAGED GARTER SPRING – REMOVE DAMAGED SPRING WITH SMALL HOOKED WIRE – INSTALL NEW SPRING IF DAMAGED OR MISSING.



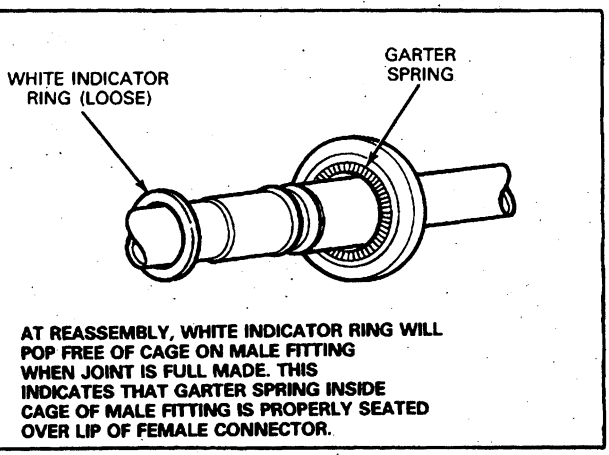
3 PUSH THE TOOL INTO THE CAGE OPENING TO RELEASE THE FEMALE FITTING FROM THE GARTER SPRING.



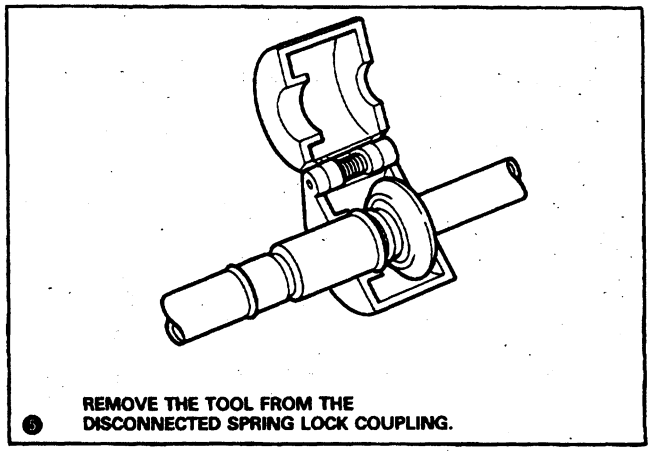
2



4 PULL THE COUPLING MALE AND FEMALE FITTINGS APART.



3 AT REASSEMBLY, WHITE INDICATOR RING WILL POP FREE OF CAGE ON MALE FITTING WHEN JOINT IS FULL MADE. THIS INDICATES THAT GARTER SPRING INSIDE CAGE OF MALE FITTING IS PROPERLY SEATED OVER LIP OF FEMALE CONNECTOR.



5 REMOVE THE TOOL FROM THE DISCONNECTED SPRING LOCK COUPLING.

K6816-2C

FIG. 26 Metal Spring Lock Connector

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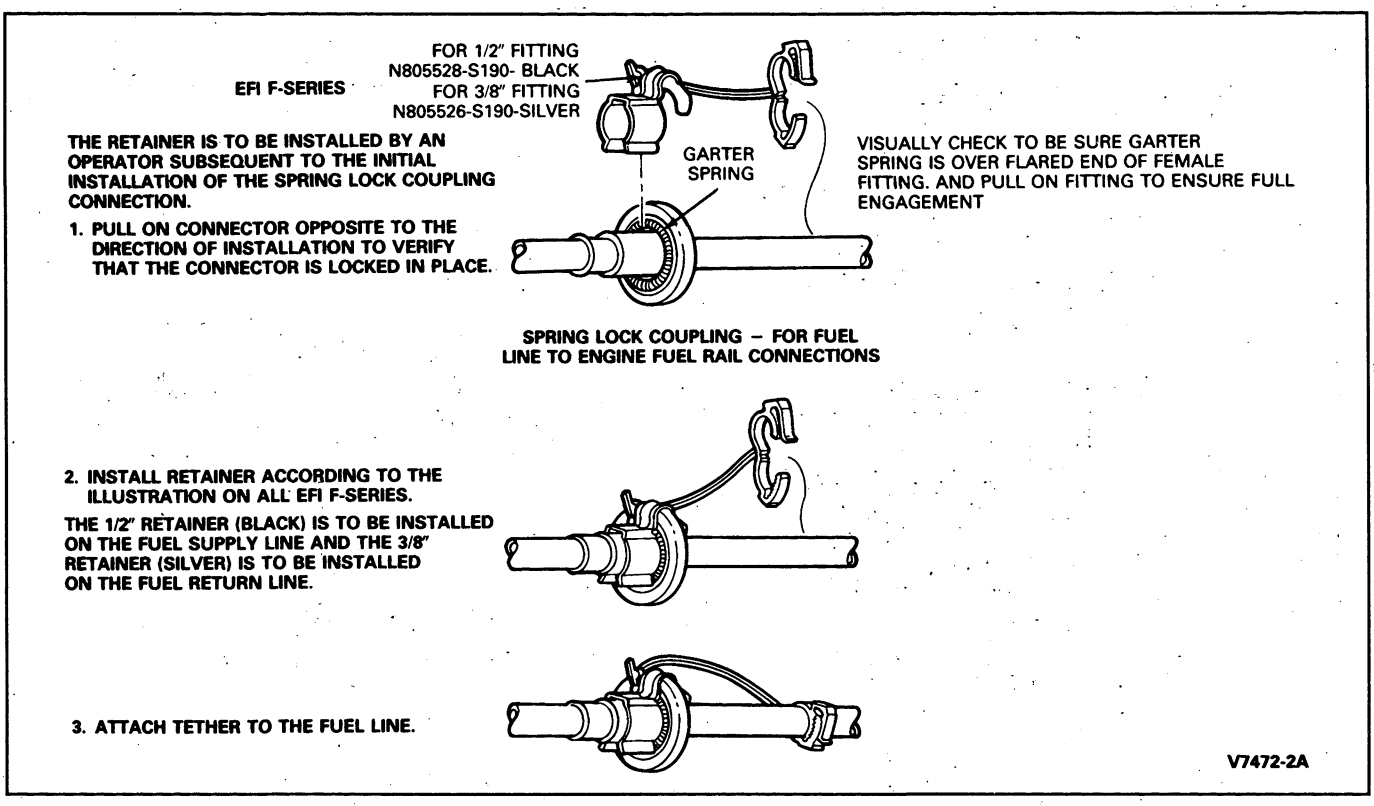


FIG. 27 Retainer Installation

5. Secure the strap ends to the T-bolts with the attaching nuts. Tighten nuts to 42-46mm (1.65-1.85 inch) exposed thread length.
6. Connect the fuel lines to the fuel gauge sending unit.
7. Connect the fuel filler hose and vent hose to the filler neck and vent neck at the tank. Tighten hose clamps to 3-4 N·m (25-35 in-lb).
8. Connect the vehicle battery ground cable removed in Step 2 of the removal procedure. Connect the fuel gauge sending unit wires.
9. Fill the tank and check all connections for leaks.

Aft Axle Frame-Mounted Tank

Removal

1. Drain the fuel into a suitable container by siphoning through the fuel line at the fuel reservoir connection.
2. Raise the rear of the vehicle.
3. To avoid electrical sparking at the tank, disconnect the ground cable on the vehicle battery.
4. Loosen the clamps on the fuel filler hose and vent hose at the fuel filler pipe assembly. Disconnect the hoses from the pipe assembly.
5. Disconnect the fuel lines, supply and return, at the front fuel tank support, **NOT** at the fuel sender.
6. Disconnect the vapor hose at the vapor tube connecting to the carbon canister. If there is a secondary hose, disconnect it from the fuel tank support crossmember.
7. Support the fuel tank in position, and loosen the strap attachment nut (at the rear) that attaches the tank strap to the upper support. Disconnect the bolt that attaches the tank strap to the front crossmember (pivot strap to the rear of the vehicle). Lower the tank enough to gain access to the fuel gauge. Disconnect the fuel gauge sending unit wires at the fuel tank.
8. Lower the fuel tank and remove it from underneath the vehicle.
9. If the fuel gauge sending unit is to be removed from the tank, disconnect the supply, return and auxiliary power take off lines from the fuel gauge sending unit. Remove six bolts (1/4 inch-20). Using care, remove fuel sender avoiding damage to the float and filter; also remove the fuel sender gasket.
10. If the upper support or the rear reinforcement is to be removed, remove nut (hold bolt) that attaches the rear reinforcement and the upper support to the frame rear crossmember.
11. Remove nut that attaches the upper support to the front crossmember and remove the support.
12. If the rear reinforcement is to be removed, remove bolt (weld nut) that attaches the reinforcement to the frame siderail.
13. If the vapor control valve is to be removed, pull it out of the seal located in the top of the tank, and remove the seal.

Installation

1. If rear reinforcement was removed, install new bolt (weld nut) attaching reinforcement to frame siderail.
2. Attach nut that retains the upper support to the front crossmember.
3. If upper support or the rear reinforcement was removed, attach the hold bolt that retained the rear

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reinforcement and the upper support to the frame rear crossmember.

4. If the fuel gauge sending unit was removed, scrape away all the old gasket material from the unit mounting surface on the fuel tank. Using a new gasket, position the fuel gauge sending unit to the fuel tank and secure with the retaining ring. Retighten the six retaining bolts to 13.5-17.5 N·m (10-13 ft-lb). Connect the fuel gauge sending unit wire.
5. If the vapor valve was removed, install new seal in the tank top opening and press fit the valve into place.
6. Raise the fuel tank high enough to connect the vapor hose to the vapor tube. Support tank in position and tighten the strap attachment bolts (at the front) to 102-142 N·m (75-105 ft-lb). Tighten the rear nuts (at the rear) to 27-34 N·m (20-25 ft-lb).
7. Attach the fuel filler hose and vent hose at the pipe assembly and tighten the clamps to 34-47 N·m (20-25 ft-lb).
8. Connect the vehicle battery ground cable.

Midship Tank

Removal

1. Drain the fuel into a suitable container by siphoning through the fuel line at the reservoir connection.
2. Raise the vehicle.
3. To avoid electrical sparking at the tank, disconnect the ground strap on the vehicle battery. Then disconnect the fuel gauge sending unit wires at the fuel tank.
4. Support the tank in position. Disengage the mounting strap ends attached to the frame side rail. Remove the other end from the tank support by rotating the strap to disengage the "T" shaped hook end.
5. Lower the tank enough to gain access to the vapor valve, fuel filler hose, fuel vent hose, and fuel lines. Loosen the attaching clamps and disconnect the lines. Disconnect the vapor valve hose from the carbon canister tube.
6. Lower the tank and remove it from underneath the vehicle.
7. If the fuel gauge sending unit is to be removed, turn the retaining ring counterclockwise and remove the sending unit, retaining ring and gasket.
8. If the vapor control valve is to be removed, pull it out of the seal located in the tank top and remove the seal.

Installation

1. If the fuel gauge sending unit was removed, scrape away all the old gasket material from the unit mounting surface on the fuel tank. Using a new gasket, position the fuel gauge sending unit to the fuel tank and secure with the retaining ring.
2. If the vapor valve was removed, install the seal in the tank opening and press fit the valve into place.
3. If the insulation tape was worn or damaged, remove the material and install new pieces approximately 419mm (16.5 inches) long, (two pieces).
4. Attach the "T" hook mounting strap ends in the tank supports. Raise the tank high enough and connect the vapor hose to the carbon canister line. Also connect the fuel filler hose, fuel vent hose, and fuel lines. Tighten the clamps that attach the hoses to the mating tank parts to 3-4 N·m (25-35 in-lb).
5. Attach the mounting straps stud end to the frame side rail with attaching nuts and tighten to 32-38mm [1.25-1.50 inches] exposed thread length.
6. Connect the vehicle battery ground cable removed in Step 3 of the removal procedure. Connect the fuel gauge sending unit wire.
7. Fill the tank and check all connections for leaks.

Bronco

The Bronco fuel tank is shown in Figure 30.

Removal

1. Drain the fuel into a suitable container at the fuel hose between the fuel pump and fuel tube.
2. Raise the rear of the vehicle.
3. To avoid electrical sparking at the tank, disconnect the ground cable on the vehicle battery.
4. Loosen the clamp on the fuel filler pipe hose at the filler pipe and disconnect the hose from the pipe by pulling along the internal fuel tube from the tank filler neck.
5. Loosen the hose clamps, slide the clamps forward and disconnect the fuel line at the fuel gauge sending unit.
6. Support the tank and remove the lower support bracket bolts or skid plate bolts. Remove the support assembly or skid plate attaching nut at each tank mounting strap. Lower the support assemblies, and lower the tank enough to gain access to the tank vent hose.
7. Disconnect the fuel gauge sending unit wire at the fuel tank.
8. Disconnect the fuel tank vent hose at the top of the tank.
9. Disconnect the fuel tank-to-vapor separator lines at the fuel tank.
10. Remove the fuel tank from under the vehicle.

If the fuel gauge sending unit is to be removed, turn the unit retaining ring. Remove sending unit and gasket.

Installation

1. If the fuel gauge sending unit was removed, make sure all the old gasket material has been removed from the mounting surface on the fuel tank. Using a new gasket, position the fuel gauge sending unit to the fuel tank and secure with the retaining ring.
2. Position the forward edge of the tank and skid plate, if so equipped, to the frame crossmember, support the tank and connect the vent hose to the top of the tank. Connect the fuel tank to vapor separator tank lines at the fuel tank.
3. Connect the fuel gauge sending unit wire to the sending unit.
4. Position the tank, skid plate and straps, and install the attaching parts. Tighten the attaching bolts and nuts to 37-50 N·m (27-37 ft-lb) using Ford

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Threadlock and Sealer E0AZ-19554-A or equivalent.

5. Connect the fuel line at the fuel gauge sending unit and tighten the drain plug, if so equipped.
6. Insert the internal fuel tube into the tank filler neck. Connect the filler pipe-to-tank hose and vent tube at the filler pipe and install the hose clamp. Tighten to 3-4 N·m (25-35 in-lb).
7. Connect the vehicle battery ground cable.
8. Fill the tank and check all connections for leaks.
9. Lower the vehicle.

Filler Pipes

F-150—F-350, Bronco and E-Series Cutaway and Stripped Chassis

Procedures are the same for the aft axle and midship fuel filler pipe (Figs. 50 through 52).

Removal

1. Drain fuel to a level (approximately 3/4 full) below the fuel tank filler connection by using the fuel hose at the fuel pump-to-fuel tube connection.
2. On Econoline, loosen clamp attaching filler pipe to tank fuel filler neck and vent hoses.
3. Detach fuel filler pipe from support bracket and disconnect fuel filler and vent hoses.
4. On F-Series, loosen clamp attaching filler pipe and disconnect hose from the pipe, pulling the internal fuel tube from tank filler neck.
5. Remove the three retainer screws that attach the filler pipe flange to the body fuel filler housing.
6. Remove fuel filler pipe from vehicle.
7. Remove hose and clamps. Replace all damaged or worn parts.

Installation

1. Position fuel filler pipe in vehicle, being careful to position neck on vehicles with internal vent tube.
2. Position fuel filler vent hoses on filler pipe of vehicles with external vent hose.
3. Position clamps on filler pipe and vent hoses.
4. Secure fuel filler pipe to mounting brackets. For F-150—F-350 and Bronco, tighten screws to 2-3 N·m (15-25 in-lb).
5. Adjust hose to obtain snug filler pipe installation. Tighten hose clamps to 3-4 N·m (25-35 in-lb). Make certain clamps are forward of flange on filler pipe to ensure a leakproof connection.
6. Fill tank with fuel. Install filler cap; check for leaks.

E-150—E-350 Vans and Club Wagons

Removal

1. Drain the fuel into a suitable container by siphoning through the fuel hose at the supply line at the fuel reservoir connection.
2. Remove the three retainer screws that attach the filler pipe flange to the body fuel filler pipe housing.
3. Loosen the clamps that attach the filler pipe to the fuel filler hose and the fuel vent hose. Disconnect the hoses.
4. Loosen the clamp that attaches the filler pipe to the support bracket at the underbody flange (aft/axle only).
5. Remove the fuel filler pipe assembly by rotating it through the opening in the underbody below the body housing assembly.

Installation

1. Install the fuel filler pipe assembly by inserting it through the underbody opening and rotating it to butt the pipe flange against the body fuel filter pipe housing.
2. Attach the pipe flange to the body fuel filter pipe housing with three retaining screws. Tighten screws to 3-4 N·m (25-35 in-lb).
3. Tighten the clamps that attach the filler pipe to the support bracket at the underbody flange to 3-4 N·m (25-35 in-lb) (aft/axle only).
4. Connect the fuel filler hose and the fuel vent hose to the fuel filler assembly. Tighten the attaching clamps to 3-4 N·m (25-35 in-lb).
5. Fill the tank, install fuel filler cap and check all connections for leaks.

MAJOR SERVICE OPERATIONS

Evaporative Emission System

WARNING: THE EVAPORATIVE EMISSION SYSTEM CONTAINS FUEL VAPOR AND CONDENSED FUEL VAPOR. ALTHOUGH NOT PRESENT IN LARGE QUANTITIES, IT STILL PRESENTS THE DANGER OF EXPLOSION OR FIRE. DISCONNECT THE BATTERY GROUND CABLE FROM THE BATTERY TO MINIMIZE THE POSSIBILITY OF AN ELECTRICAL SPARK OCCURRING, POSSIBLY CAUSING A FIRE OR EXPLOSION IF FUEL VAPOR OR LIQUID FUEL ARE PRESENT IN THE AREA.

Evaporative emission components have been designed and tested to exceed 193,116 Km (120,000 miles) or 10 years of vehicle use. No maintenance or servicing should be required. However, if components have been damaged and are to be replaced, or if disconnection or removal is required for diagnosis, the following techniques should be used to aid servicing the system.

Typical evaporative emission systems are shown in Figs. 6 through 15.

To disconnect a hose from any component, refer to the following:

1. Securely grip component with one hand, and hose with the other hand as close as possible to connection.
2. Sharply twist hose along its axis to "break" the temporary bond between hose and component. (No adhesive is used to make hose connections during vehicle assembly, but natural aging of the connections causes a temporary bond to exist.)
3. It is important to "break free" the hose at its connection point as indicated in Step 2. If the joint is stubborn and the above method does not work, grip the hose with a pair of pliers directly over the joint and twist again.
4. Once the hose/component joint has been broken, disconnect by securely gripping the component

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with one hand and hose with the other. Twist hose and at the same time pull apart.

WARNING: MOST CONNECTIONS IN THE EVAPORATIVE EMISSION SYSTEM ARE VERY SECURE. A STRONG PULLING AND SIMULTANEOUS TWISTING ACTION IS REQUIRED TO DISCONNECT. WHEN DISCONNECTION OCCURS, BOTH HANDS COULD SHARPLY AND UNCONTROLLABLY MOVE IN THE DIRECTION OF EACH HAND'S PULLING. BE CAREFUL THAT NO SHARP OR POSSIBLE DAMAGING OBJECTS ARE IN LINE WITH THE DIRECTION OF PULL TO PREVENT PHYSICAL INJURY AND/OR DAMAGE TO THE OBJECTS THAT WILL BE IMPACTED BY THE HANDS WHEN DISCONNECTION OCCURS.

To reconnect a hose to a component, wet the hose and push onto component.

Use Ford-approved fuel hoses for replacement of damaged hoses. Original equipment hoses are designed to resist most environmental conditions encountered in the evaporative emission system.

Fuel Tanks

Fuel tanks do not require special service procedures and may be steam-cleaned and/or serviced using standard procedures. After steaming, allow time to thoroughly air dry. The vapor separator assembly should be replaced. Replace fuel tank strap bolts.

Electric Fuel Pumps

An electric fuel pump is located in the fuel tank. The pump is attached to the fuel tank as part of the sender unit. The fuel tank must be removed to service the fuel pump. Care should be taken during installation due to the hose and wire routing on the tank. Be sure all hoses and wires are routed properly. Check the fuel line connections for leaks.

NOTE: Remove the fuel pump prior to steaming the fuel tank.

For electric fuel pump service, refer to Section 24-35, Fuel Pump—Electric.

WARNING: FUEL SUPPLY LINES ON VEHICLES EQUIPPED WITH FUEL INJECTED ENGINES WILL REMAIN PRESSURIZED FOR LONG PERIODS OF TIME AFTER ENGINE SHUT-DOWN. THE PRESSURE MUST BE RELIEVED BEFORE SERVICING THE FUEL SYSTEM.

Refer to Fuel System Pressure Relief.

Fuel Lines

Vehicles equipped with nylon fuel tubes and push connect fittings have three types of service that can be performed to the fuel lines: replacing nylon tubing (splicing nylon to nylon), replacing push connector fittings, and replacing damaged push connect tube end.

Splicing Nylon to Nylon

1. Relieve fuel system pressure as outlined. Read cautionary note prior to relieving pressurized fuel system.
2. Cut out damaged section of tubing and retain as a guide.
3. Cut a section of service tubing (type 11 or 12 nylon available in 6.3mm (1/4 inch), 9.5mm (3/8 inch), 7.9mm (5/16 inch) sizes) to the same length as the damaged section of tubing.
4. Select the proper 9.5mm (3/8 inch) or 7.9mm (5/16 inch) barbed connectors for completing the splice. Two connectors are required for each splice (Fig. 29).

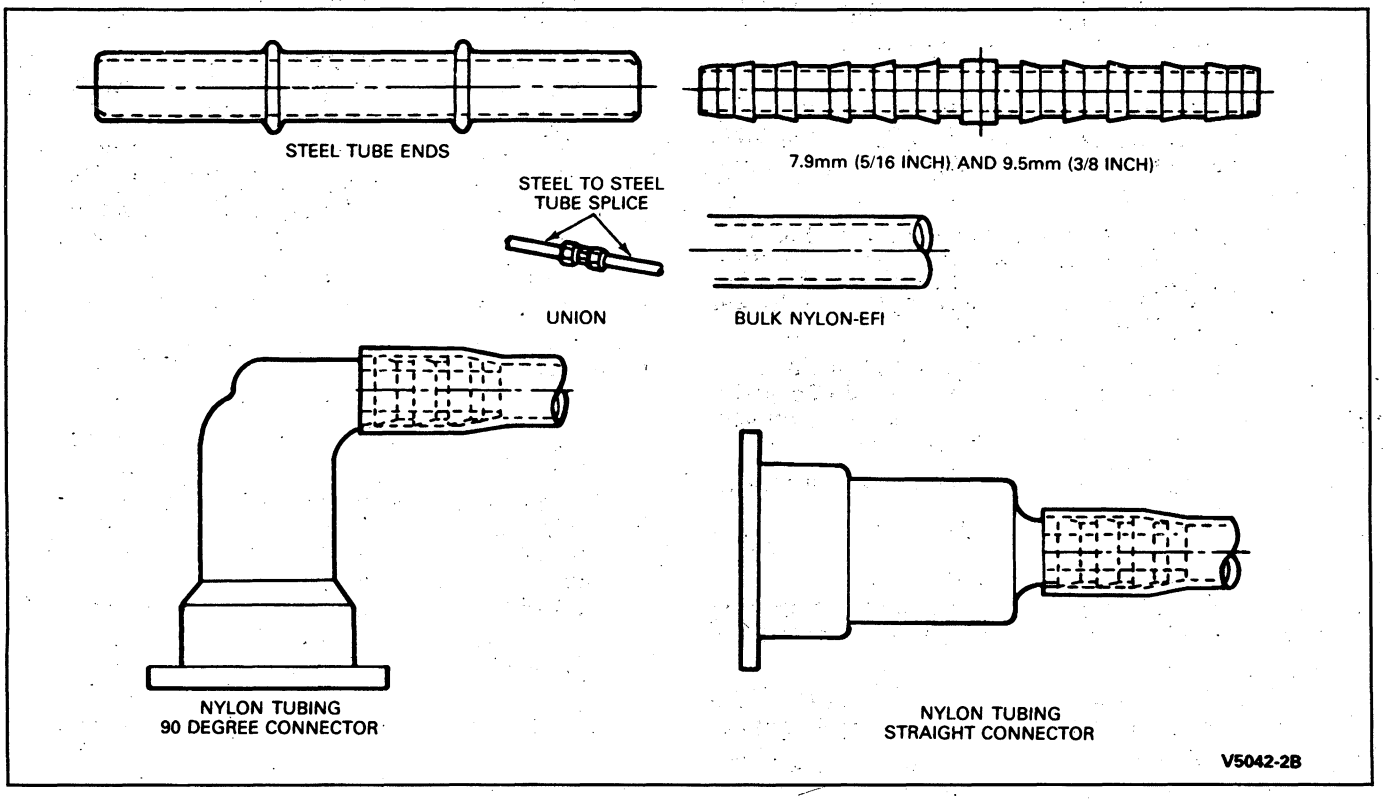


FIG. 28 Fuel Line Service Parts

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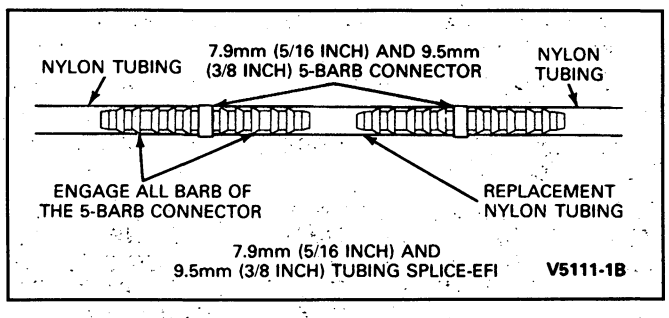


FIG. 29 Splicing Service Combinations

NOTE: To make hand insertion of the barbed connectors into the nylon easier, the tube end must be soaked in a cup of boiling water for one minute immediately before pushing the barbs into the nylon using Rotunda Tool 134-00001 or equivalent to assist assembly.

5. Install the barbed connectors into each end of the replacement tubing using boiling water and special tool as outlined.
6. Install clips onto any tubes which might be difficult to access once the final splices are completed.
7. Complete the splice of the replacement nylon to the original nylon tubing at both ends. Use the boiling water method and special tool as mentioned previously, to get the required number of barbs engaged (Fig. 29).
8. Install any remaining clips which were removed for this service and check that the tubes are secure in the original clips.
9. Start engine and check for leaks.

Replacing Damaged Push Connectors

1. Relieve fuel system pressure as outlined. Read the cautionary note prior to relieving the pressure in the fuel system.

   NOTE: Damaged push connectors must be discarded and replaced with new push connectors. If only the retaining clip is damaged, replace the clip.
2. Disconnect the damaged push connector. Be sure to bend the shipping tab to the side before removing retaining clip. The spring lock connector requires the use of the Spring Lock Coupling Tool D87L-9280-A or B or equivalents (Fig. 26).
3. Select the proper size replacement push connector and nylon tube assembly. In some instances, the new connector will not be available with a nylon line attached. In this instance, it be necessary to attach a section of line.
4. Cut out a section of the original nylon tube to the same length as the nylon tube attached to the new push connector.
5. Install proper barbed connector into the replacement nylon assembly.

   NOTE: To make hand insertion of the barbed connectors into the nylon easier, the tube end may be soaked in a cup of boiling water for one minute immediately before pushing the barbs into the nylon (Fig. 29).
6. Complete the splice by connecting the barbed connector to the original nylon. Refer to Fig. 29 for the proper barb insertion.
7. Connect the new connector assembly to the tube end.
8. Check that the underbody clips are properly securing the fuel tubes.
9. Start engine and check for fuel leaks.

Replacing Damaged Steel Push Connect Tube Ends

1. Relieve fuel system pressure as outlined. Read the cautionary note prior to relieving the pressure in the fuel system.
2. Using a tube cutter, remove the damaged push connect tube end at a convenient distance from the end.

   NOTE: Allow for adequate room to tighten a union with a wrench at this location.
3. Choose a proper replacement push connect tube end (Fig. 28).
4. If required, form the new tube end to the same shape as the damaged tube end which was removed.
5. Select the proper size union (Fig. 28) and attach the new steel tube end to the original tube.
6. Clean off the steel tube end and replace the push connector onto the tube. (A new retainer clip is recommended.)
7. Check that the fuel tubes are properly secured.
8. Start engine and check for leaks.

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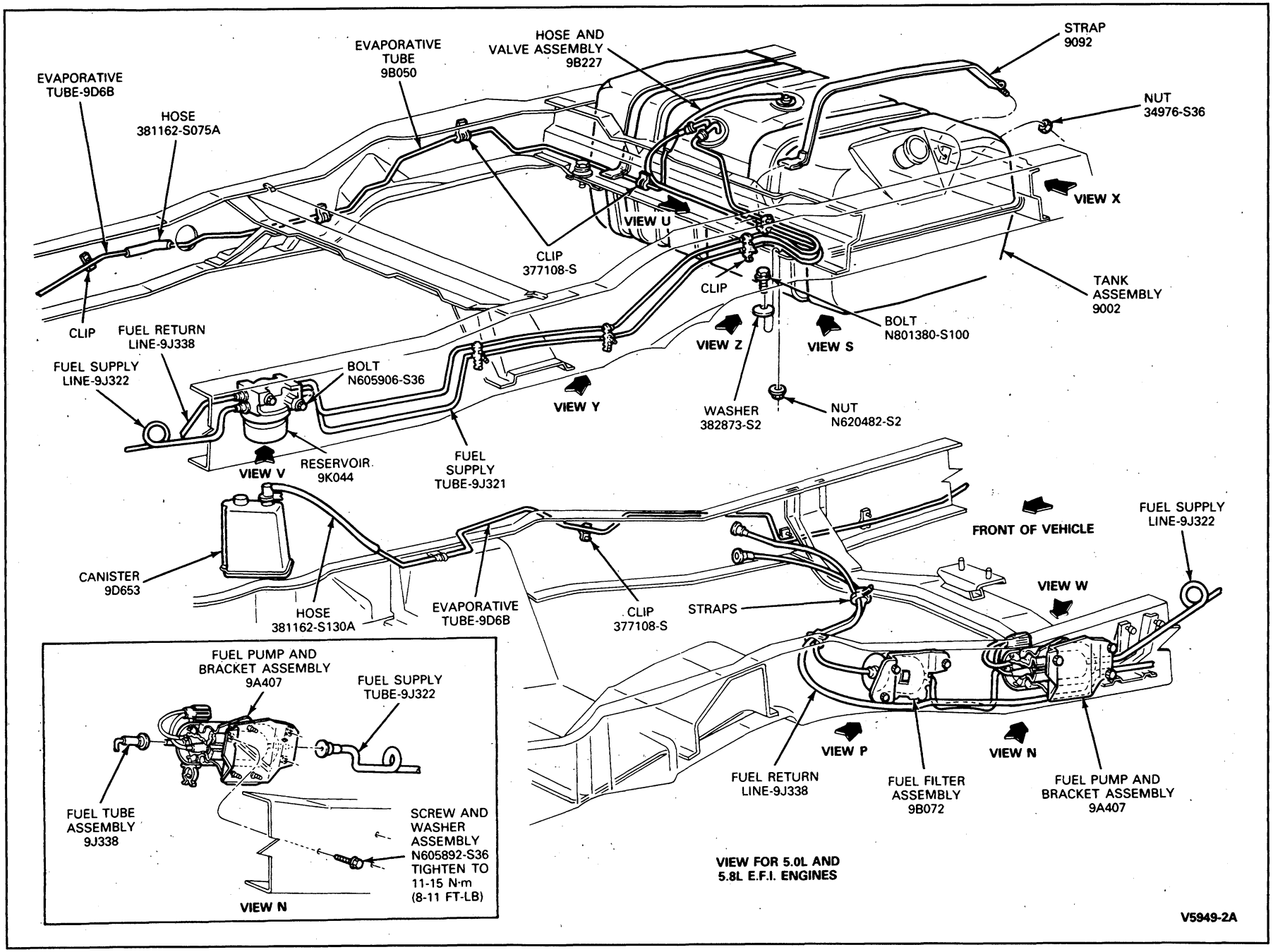


FIG. 30 Bronco (4x4) Fuel Tank Installation

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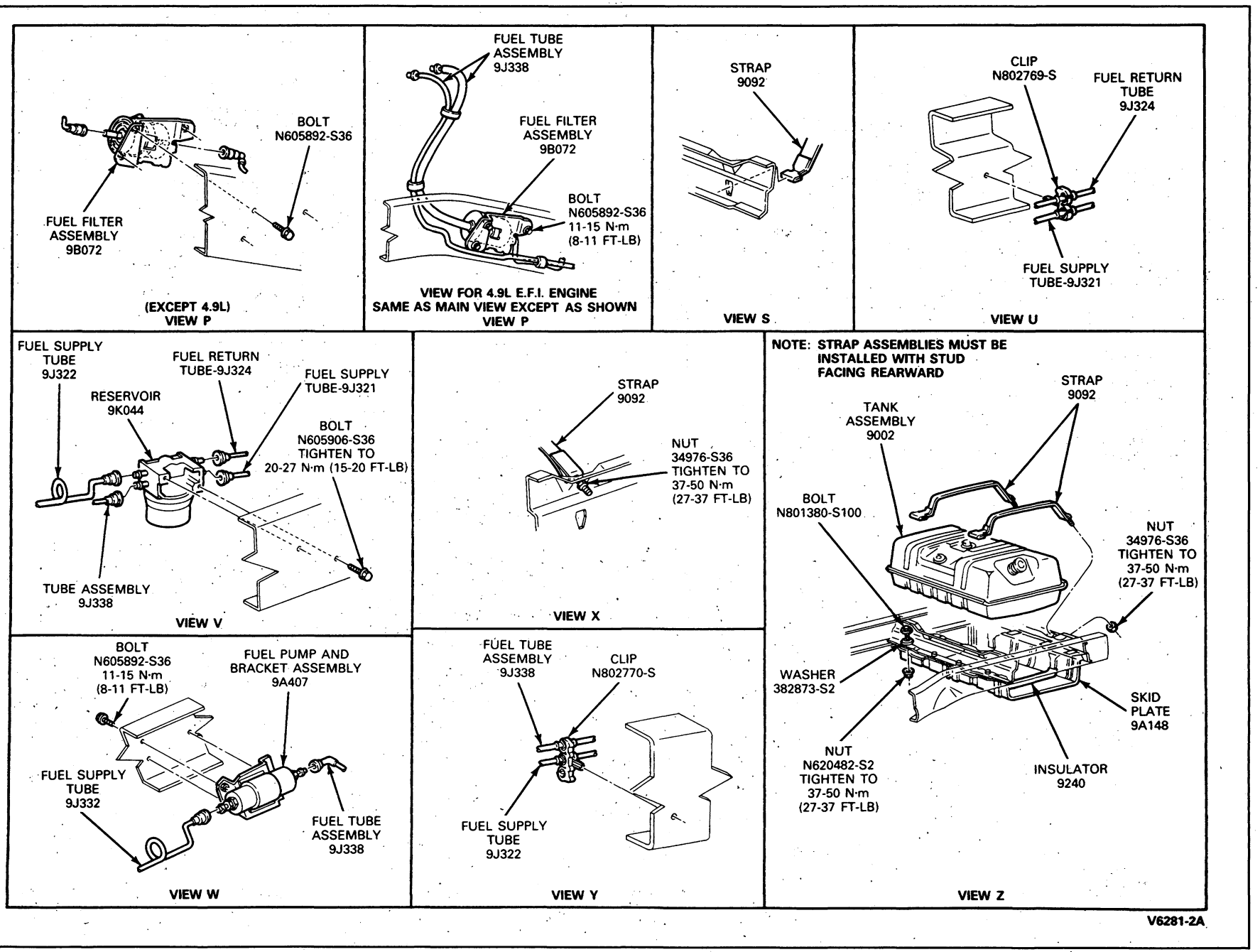


FIG. 31 Bronco (4x4) Fuel Tank Installation — 4.9L EFI Engine

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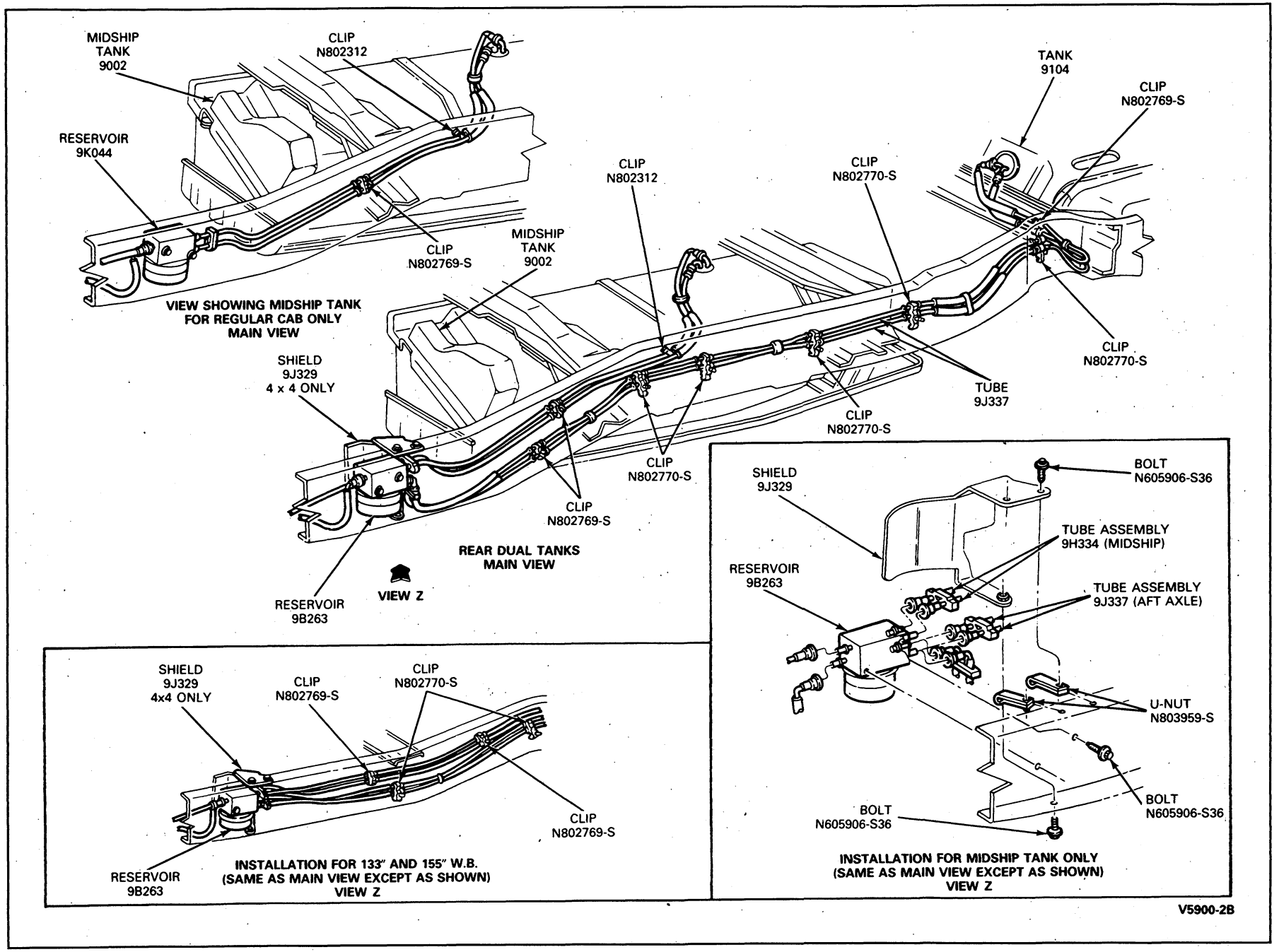


FIG. 32 Fuel Line Installation—F-150—F-350—4.9L EFI, 5.0L EFI, 5.8L EFI and 7.5L EFI Engines

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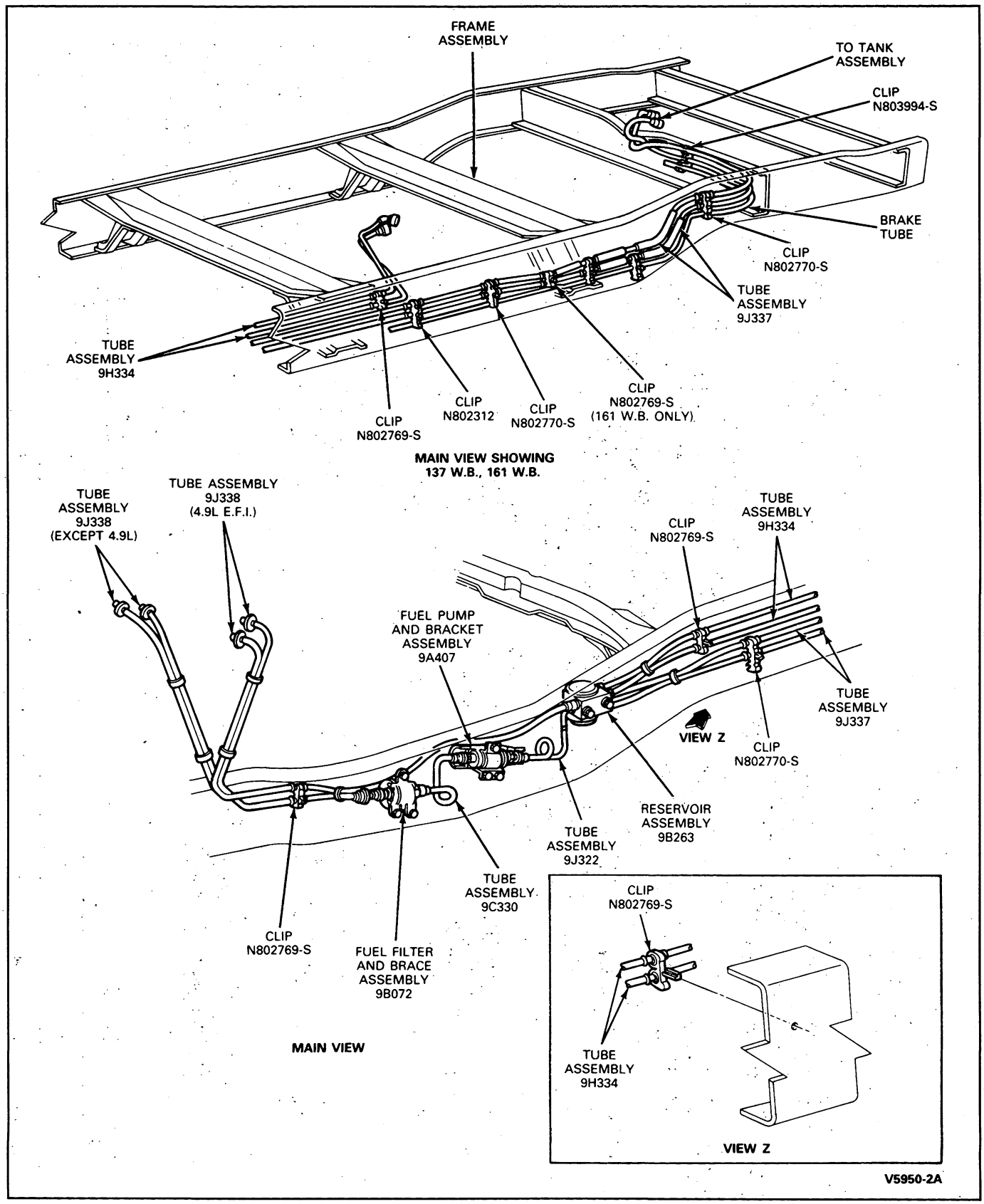


FIG. 33 Fuel Line Installation—F-350, 136.8 and 160.8 Inch Wheelbase Chassis Cab

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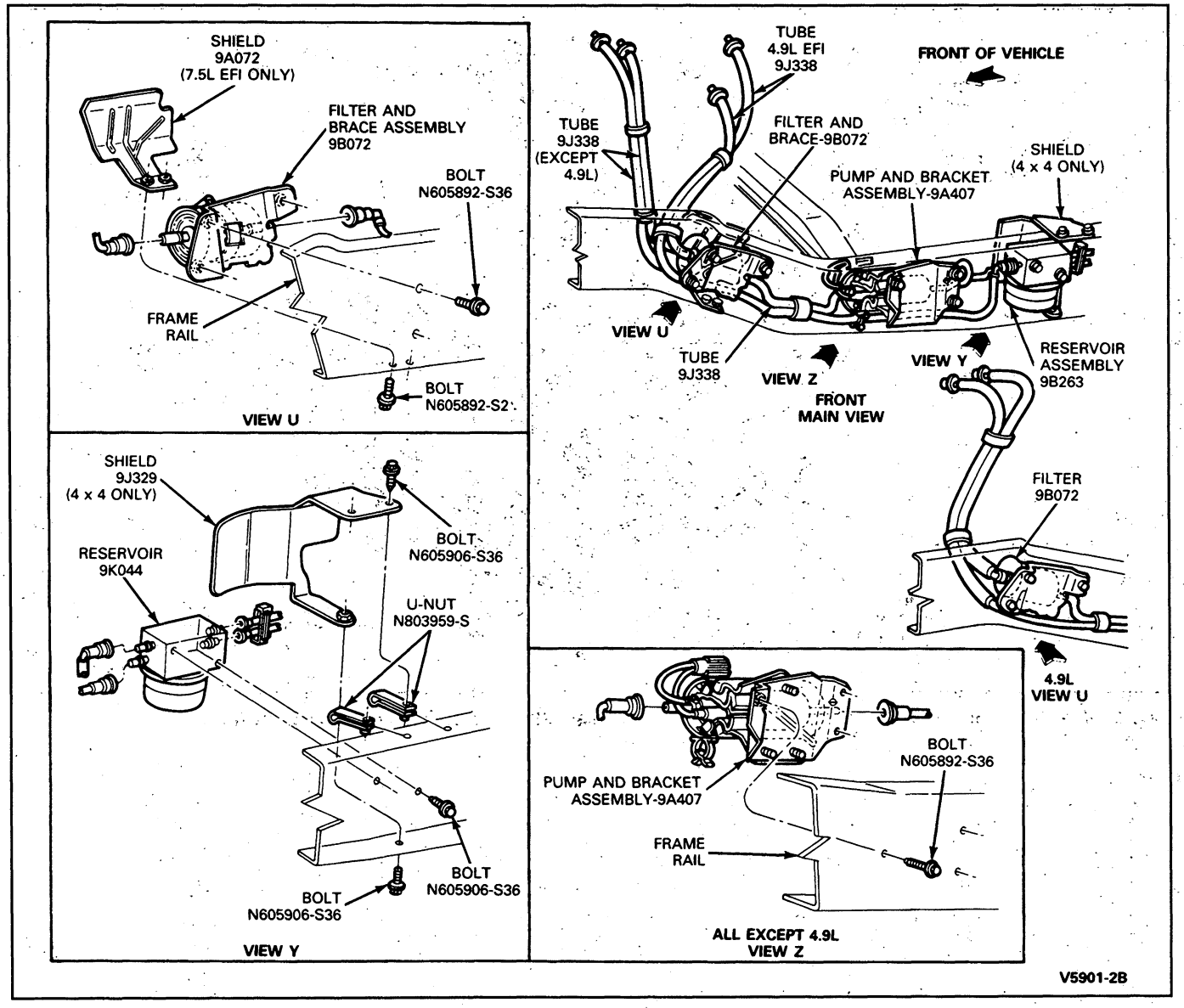


FIG. 34 Fuel Pump and Filter Installation—F150—F350—4.9L EFI, 5.0L EFI and 7.5L EFI

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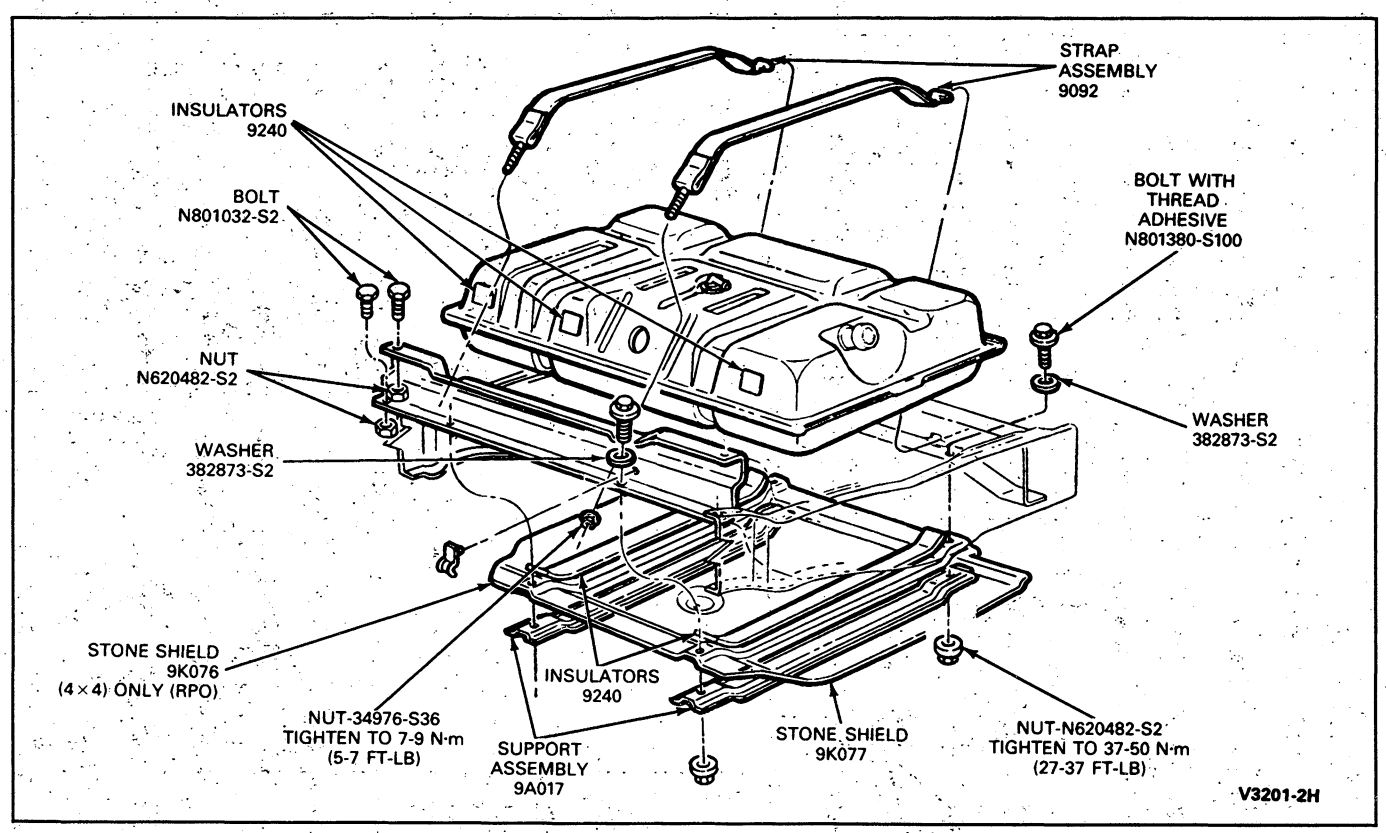


FIG. 35 F-150—F-350-116, 133, 138 and 155 Inch Wheelbase Steel Aft-Axle Fuel Tank Installation

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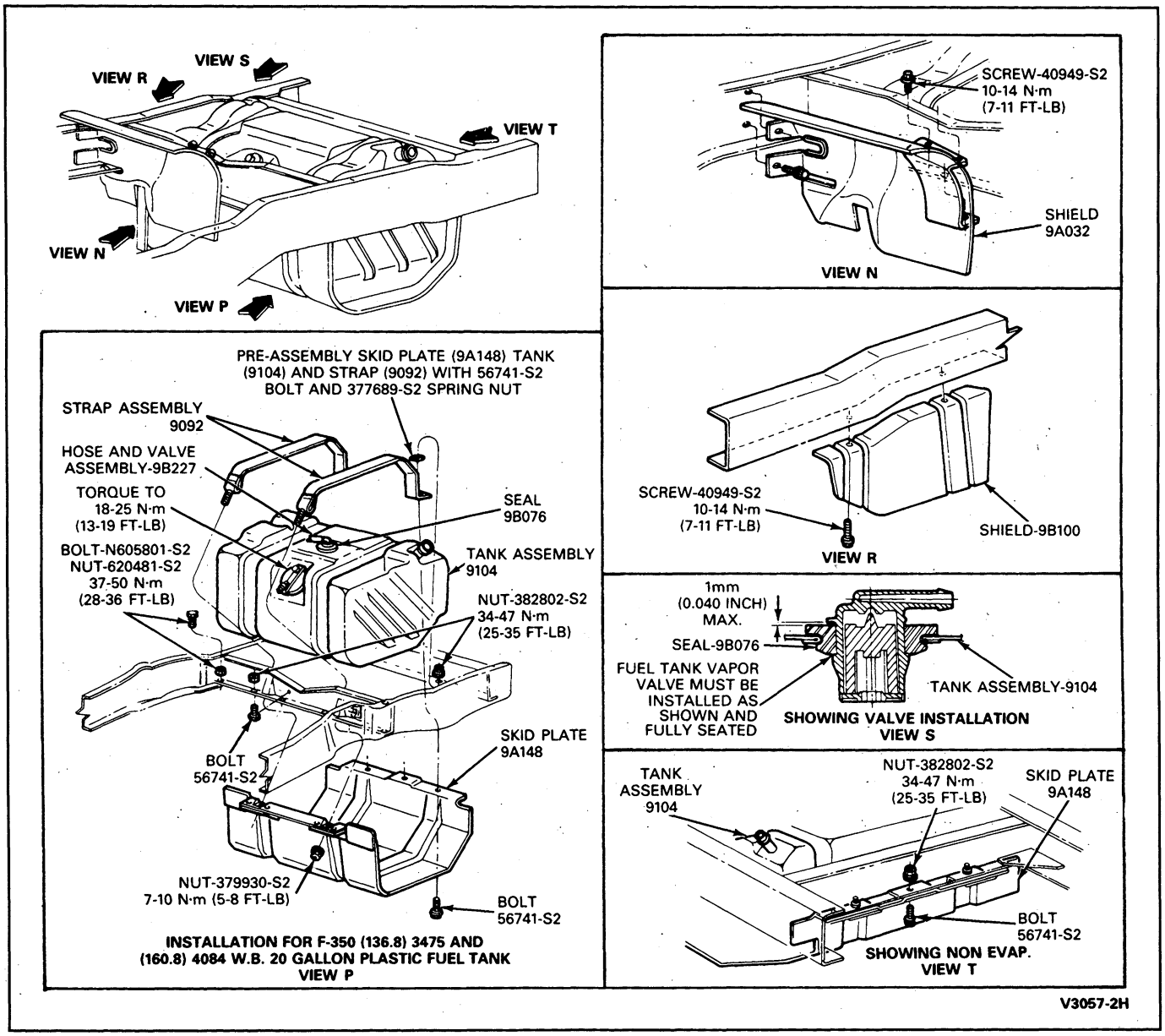


FIG. 36 F-350—136.8 and 160.8 Inch Wheelbase Plastic Aft Fuel Tank Installation

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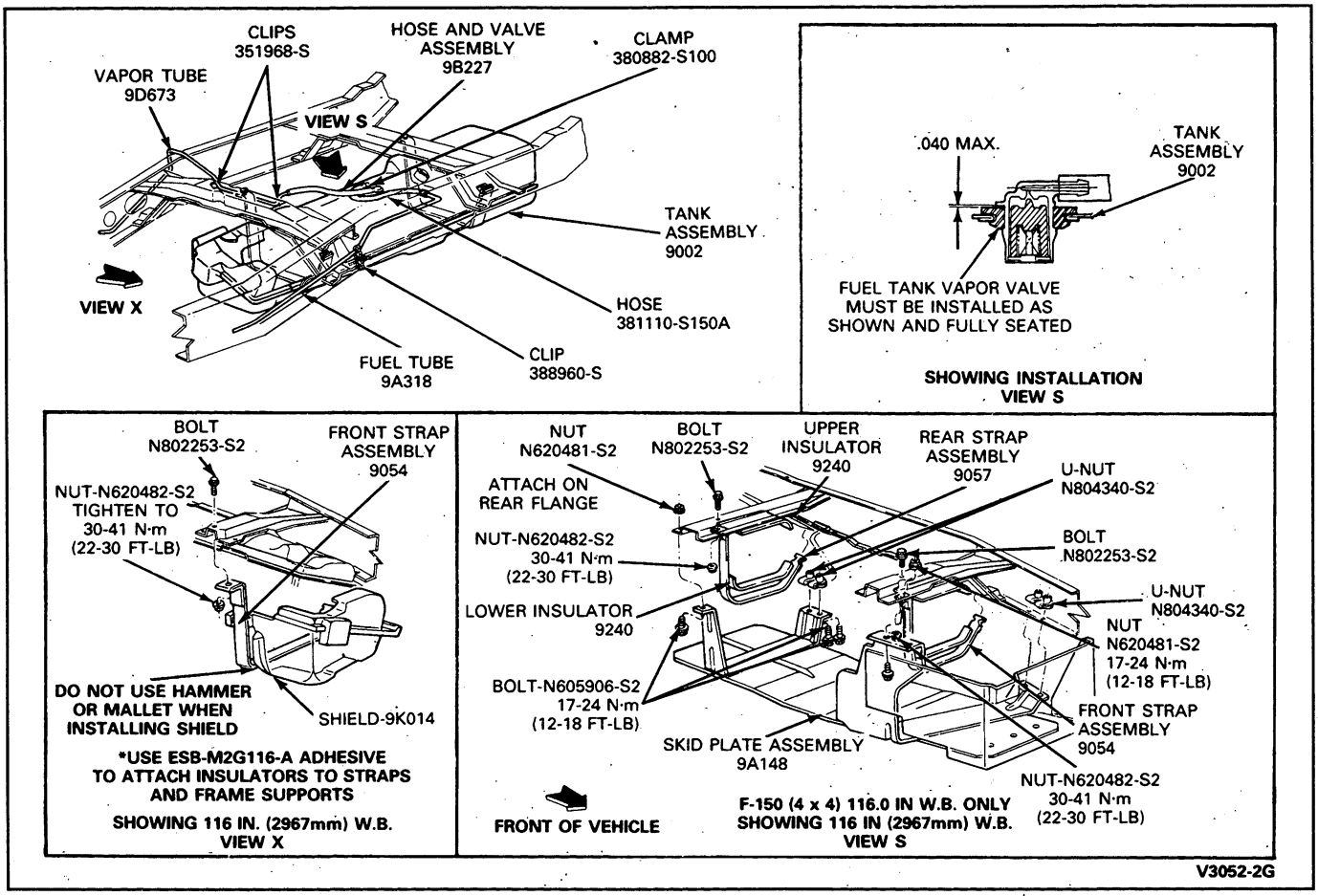


FIG. 37 F-150 (4x2)—116 and 138.6 Inch Wheelbase, F-150 (4x4) 116 Inch Wheelbase, and F-250 (4x2) 138.8 Inch Wheelbase Midship 16.5 Gallon Fuel Tank Installation

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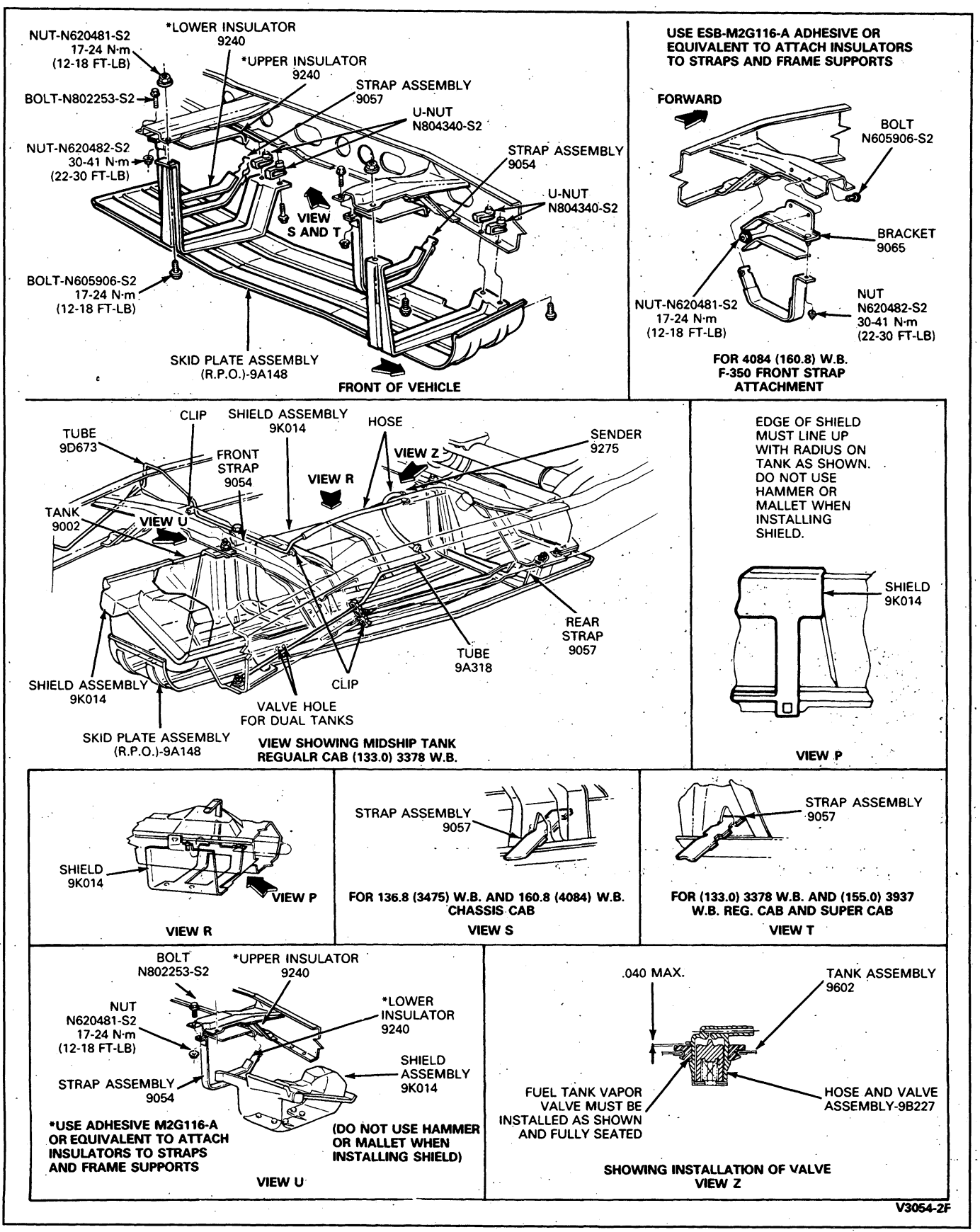


FIG. 38 F-150—F-350 Fuel System—Midship 19 Gallon Tank

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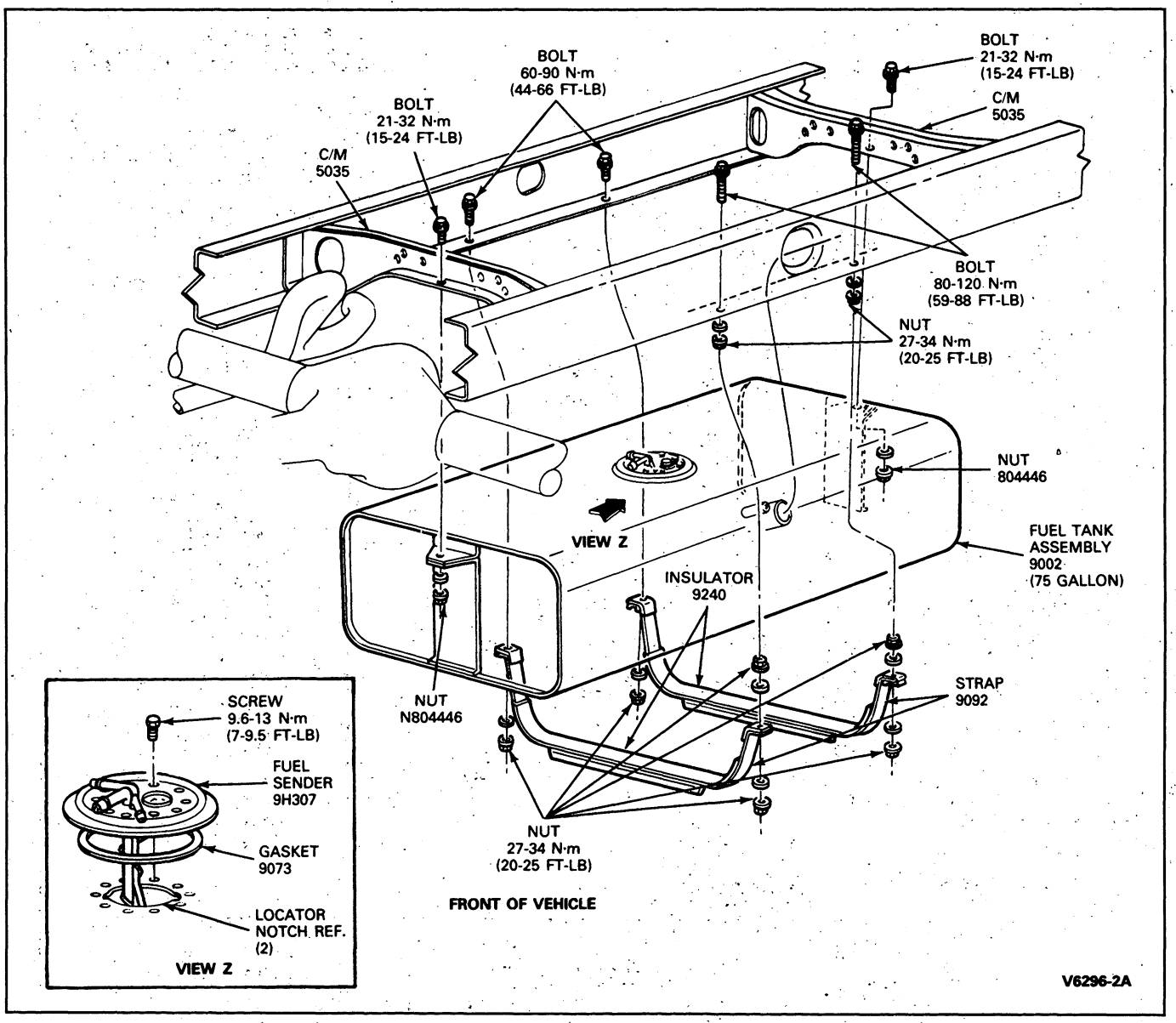


FIG. 39 F-Super Duty Motor Home Chassis—Aft Axle 75 Gallon Tank

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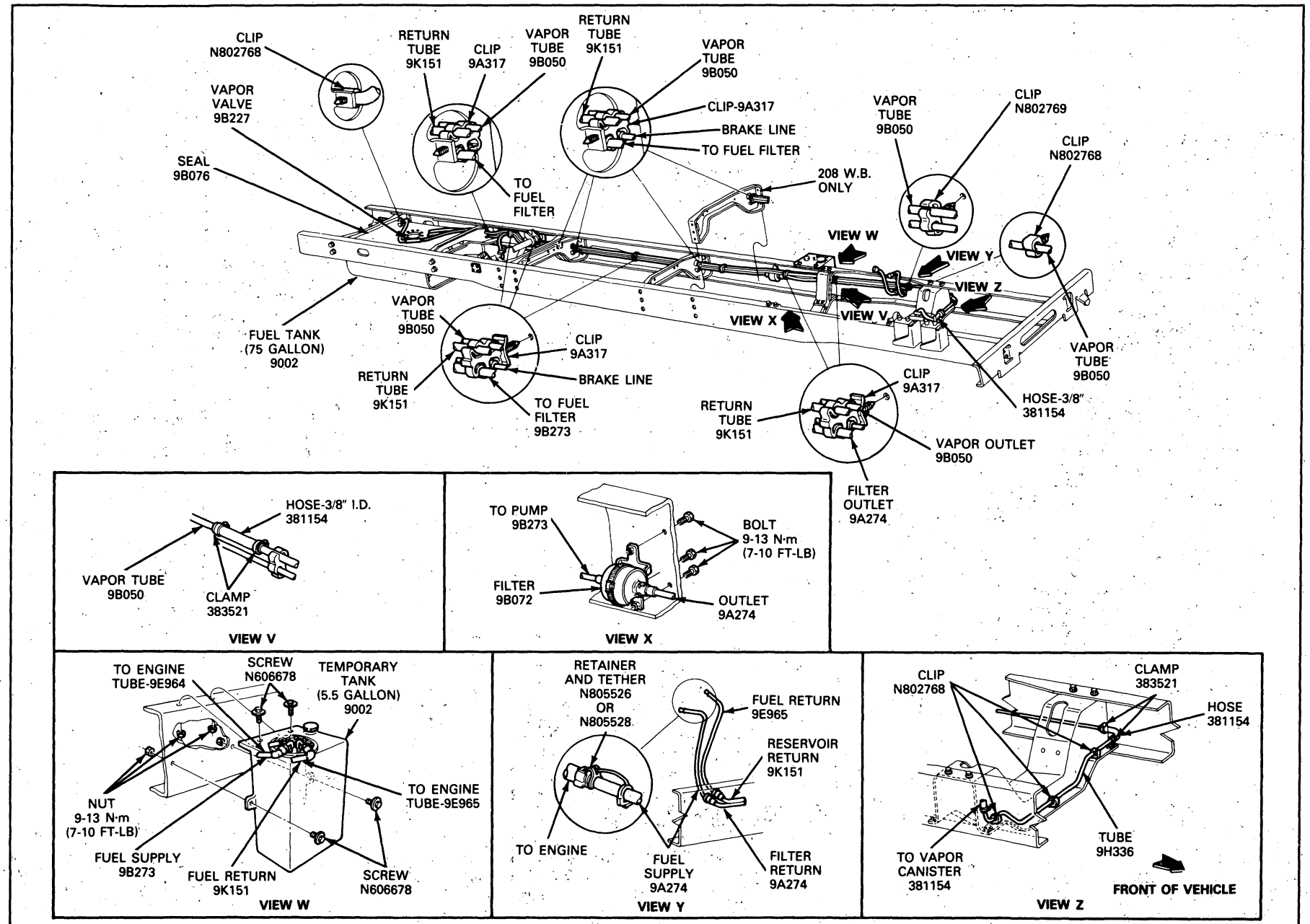


FIG. 40 F-Super Duty Motor Home Chassis—Fuel Lines

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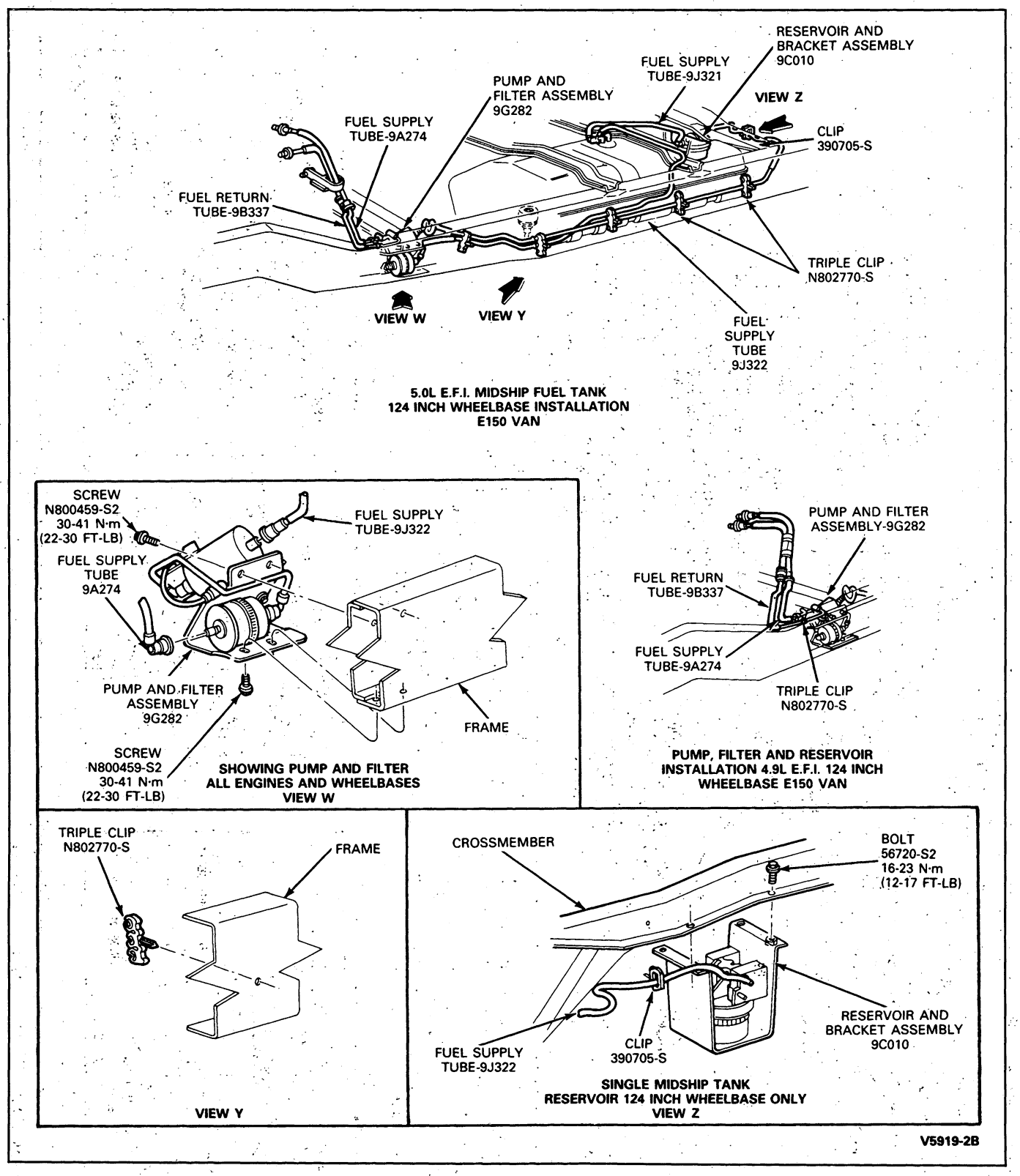


FIG. 41 Fuel Line Installation—E-150—124 Inch Wheel Base

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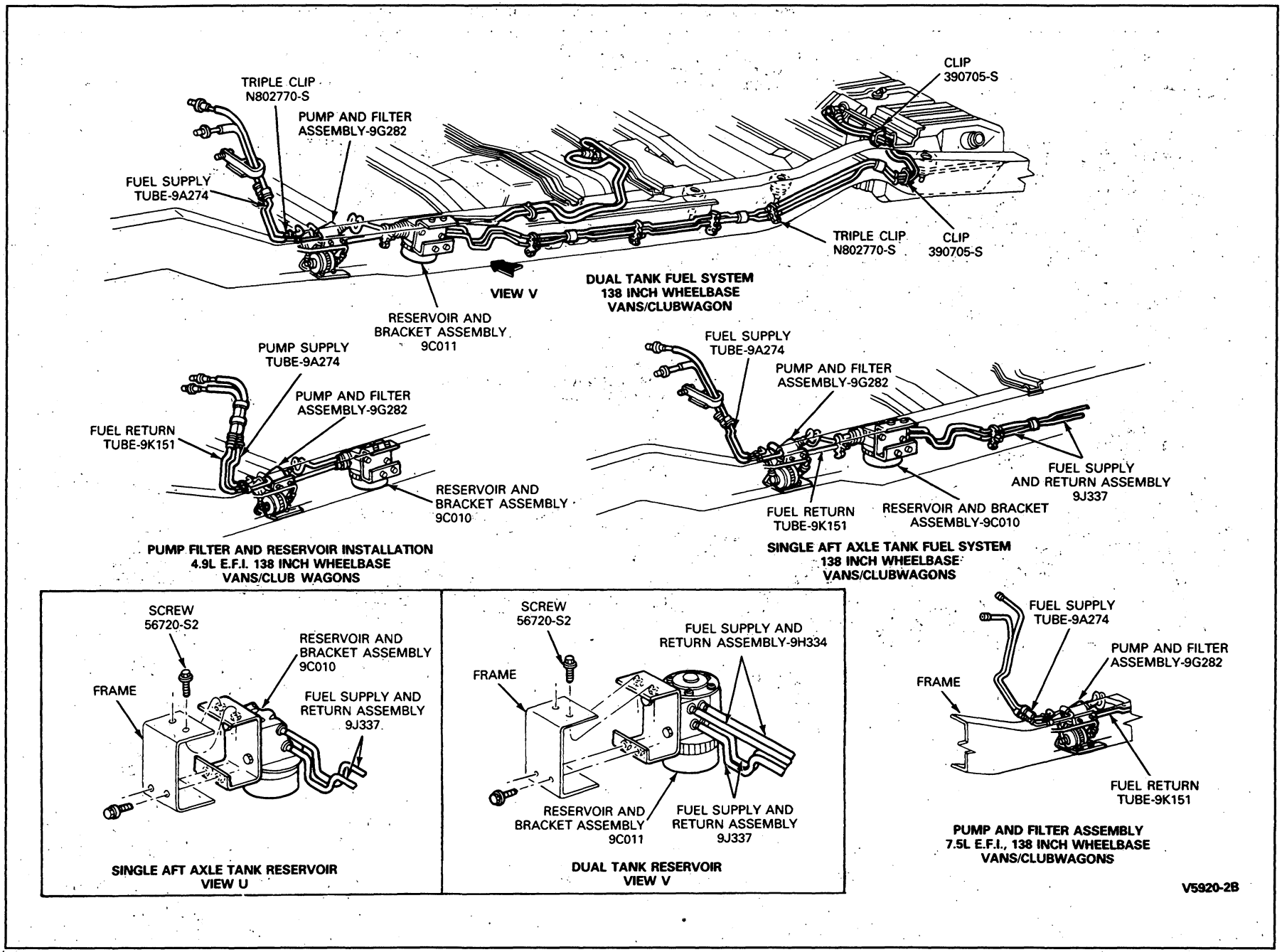


FIG. 42 Fuel Line Installation—E-150—E-350—138 Inch Wheel Base

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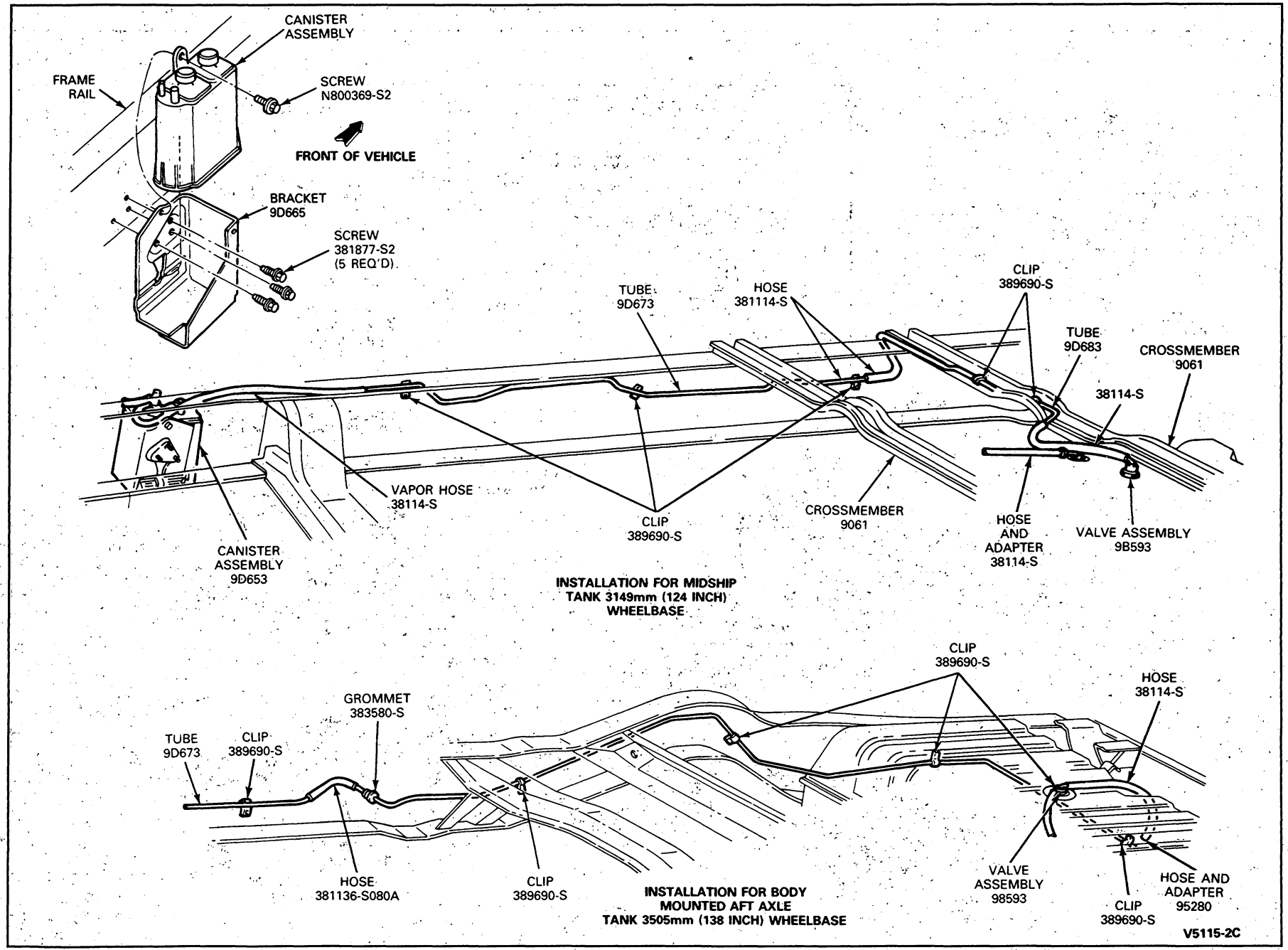


FIG. 43 E-150—E-350 Typical Evaporative Fuel System Installation—4.9L and 5.0L EFI Engines

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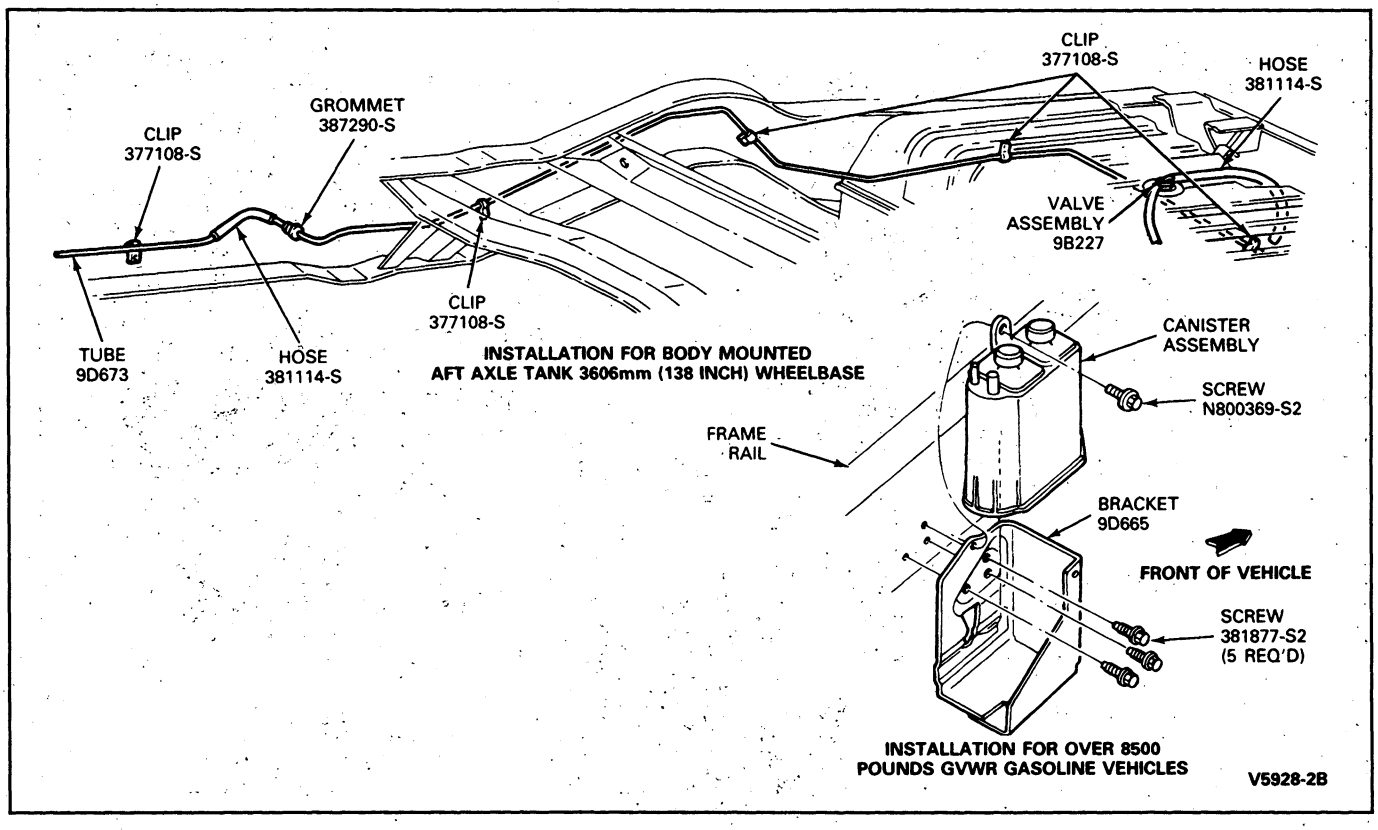


FIG. 43A E-150—E-350 Typical Evaporative Fuel System Installation—4.9L and 5.0L Engines (Cont.)

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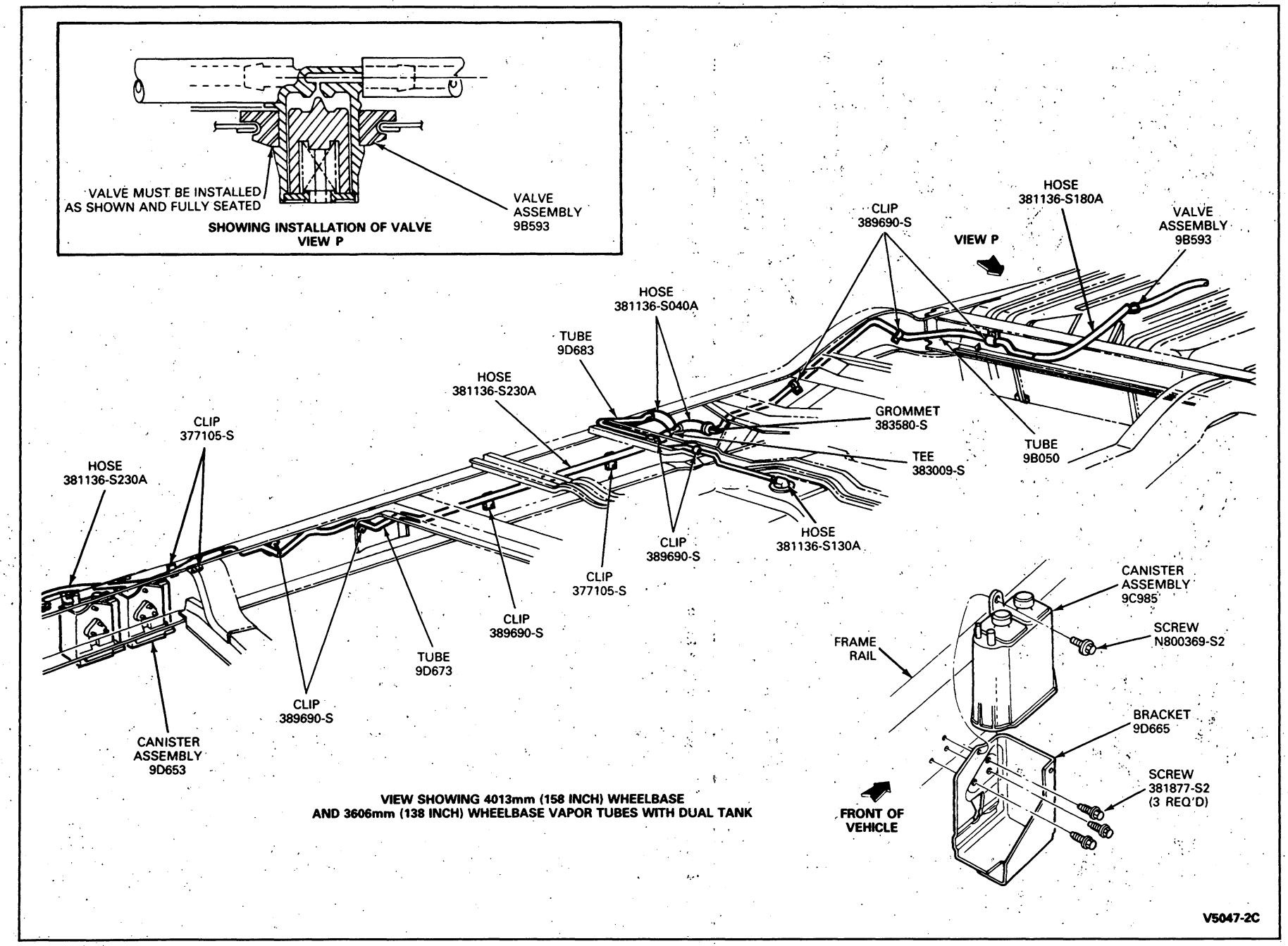
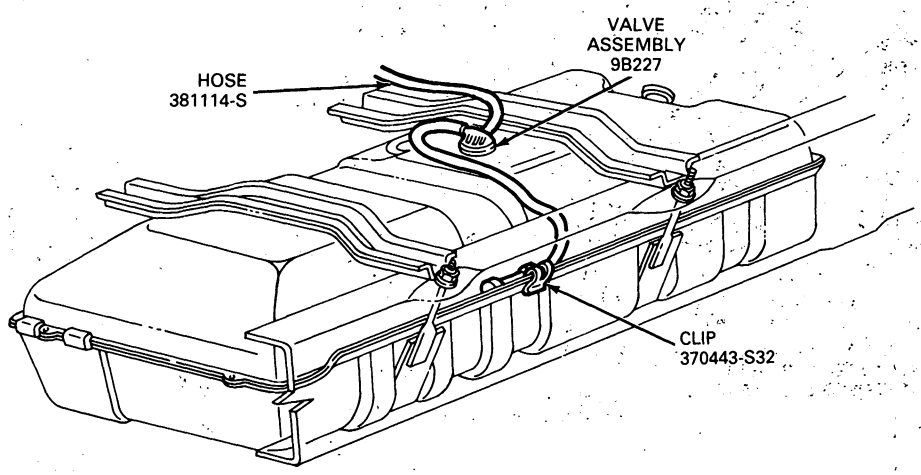
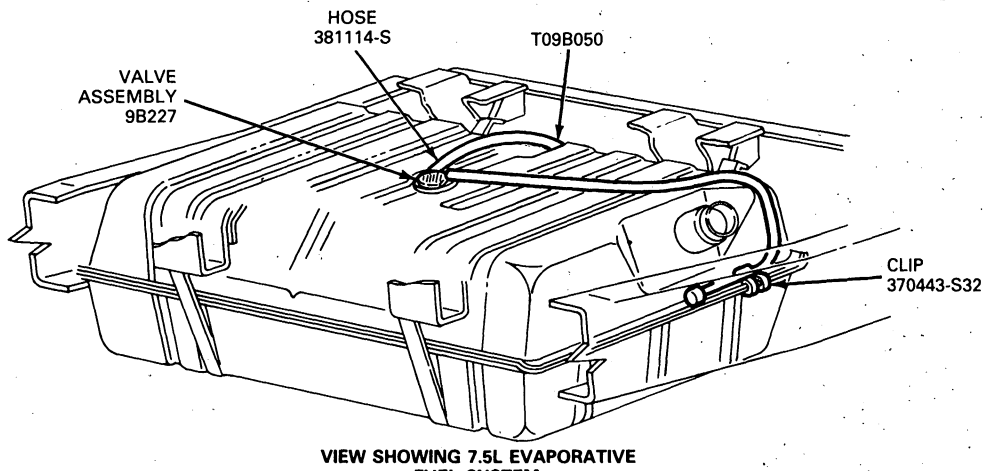


FIG. 43B E-150—E-350 Typical Evaporative Fuel System Installation—5.8L and 7.5L EFI Engines

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VIEW SHOWING 7.5L EVAPORATIVE
FUEL SYSTEM
(MID-SHIP TANK)



VIEW SHOWING 7.5L EVAPORATIVE
FUEL SYSTEM
(AFT/AXLE TANK)

V5046-2B

FIG. 44 E-250—E-350 Typical Evaporative Fuel System Installation—5.8L and 7.5L EFI Engines

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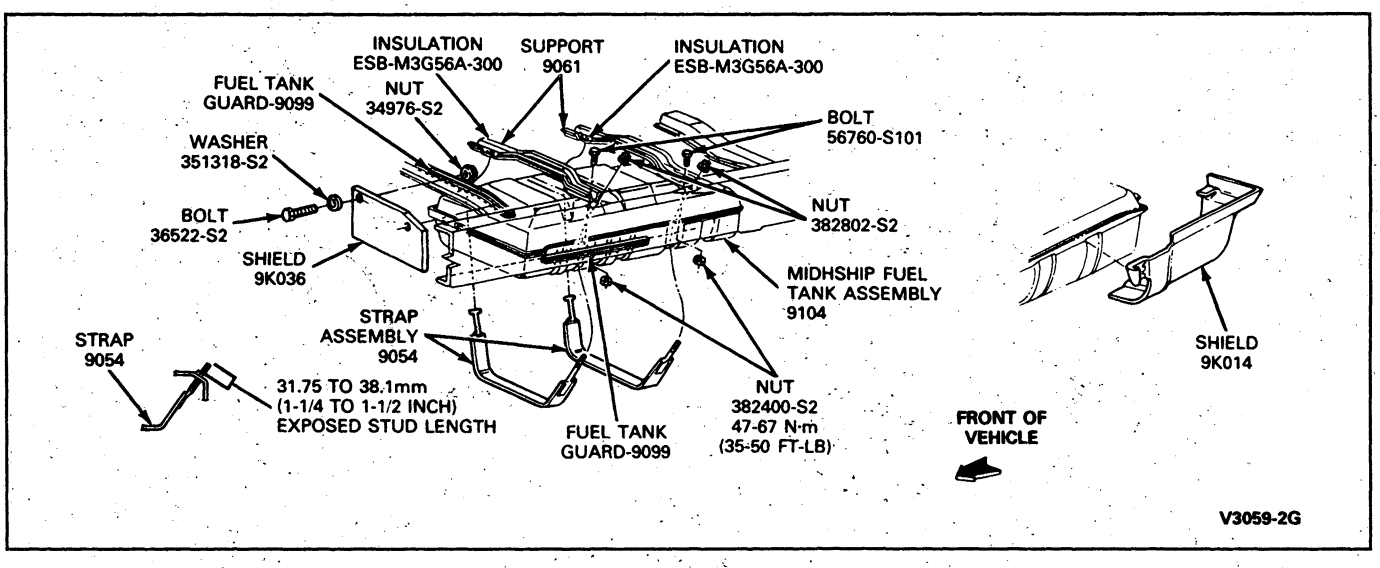


FIG. 45 E-150—E-350 Midship Fuel System Installation—Tank Installation

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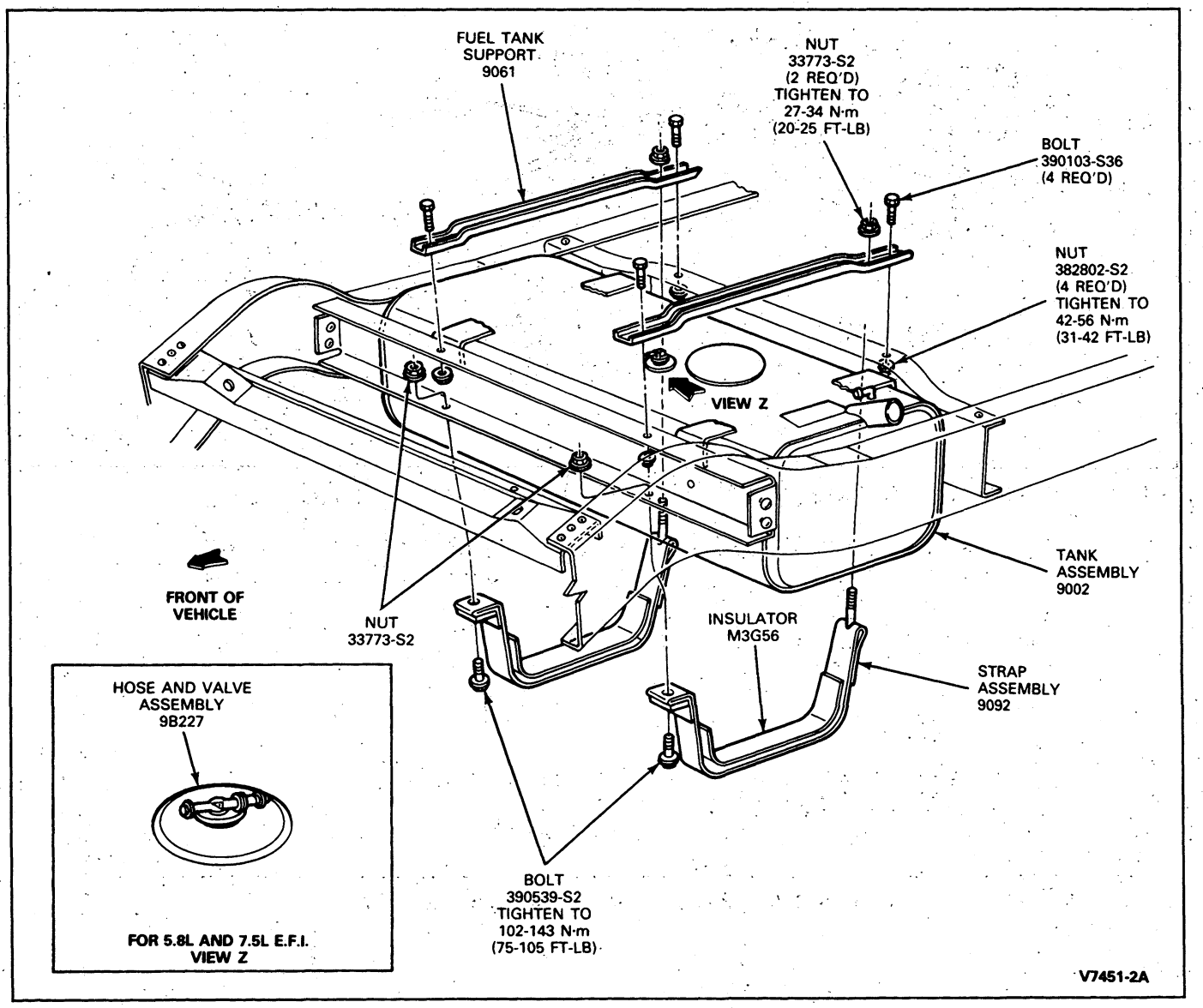


FIG. 46 E-350 R.V. and Commercial Cutaway and Stripped Chassis—Fuel System Installation—36 Gallon Tank

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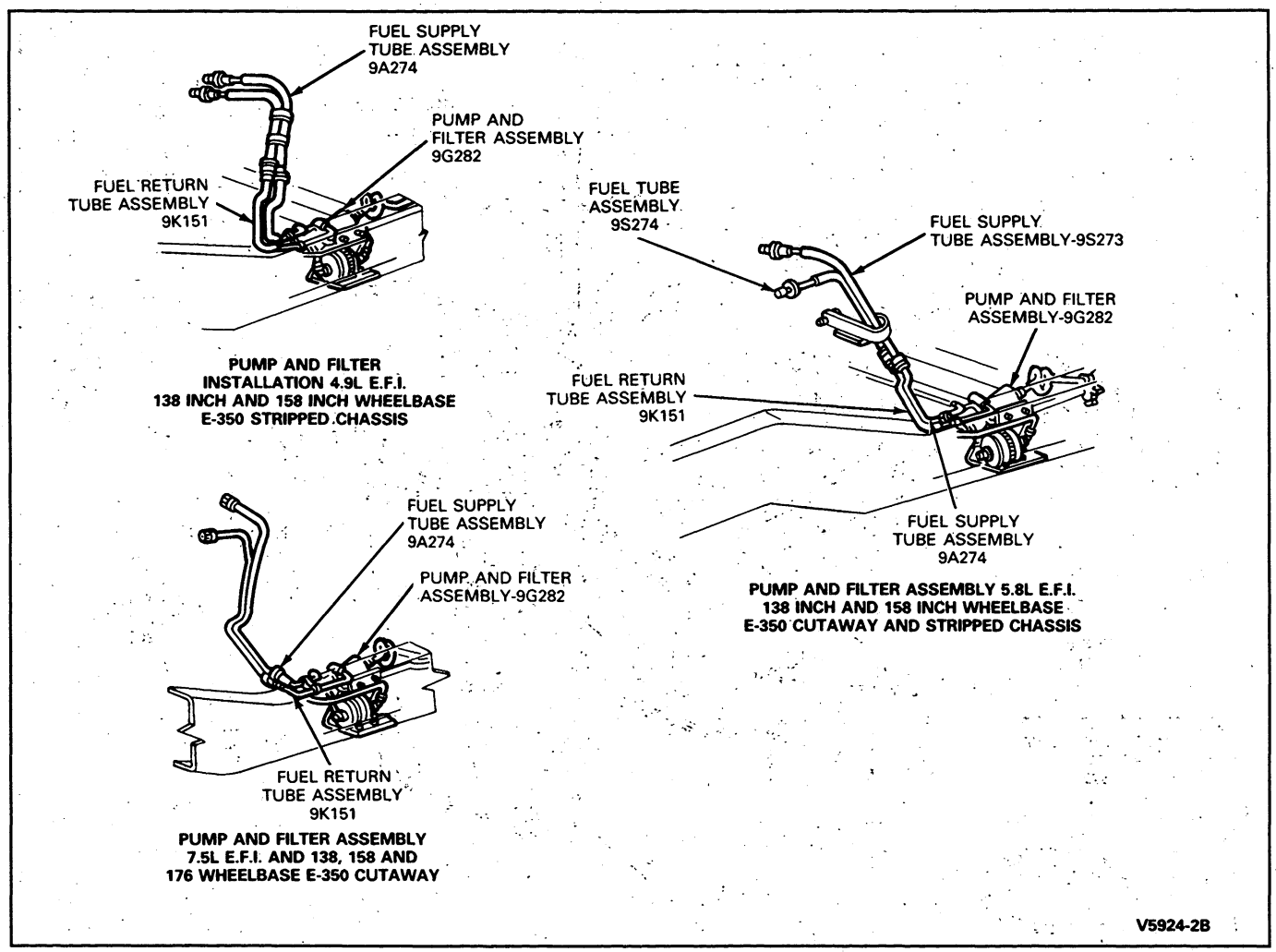


FIG. 47A E-350 R.V. and Commercial Cutaway—Fuel System Installation—(Cont'd.)

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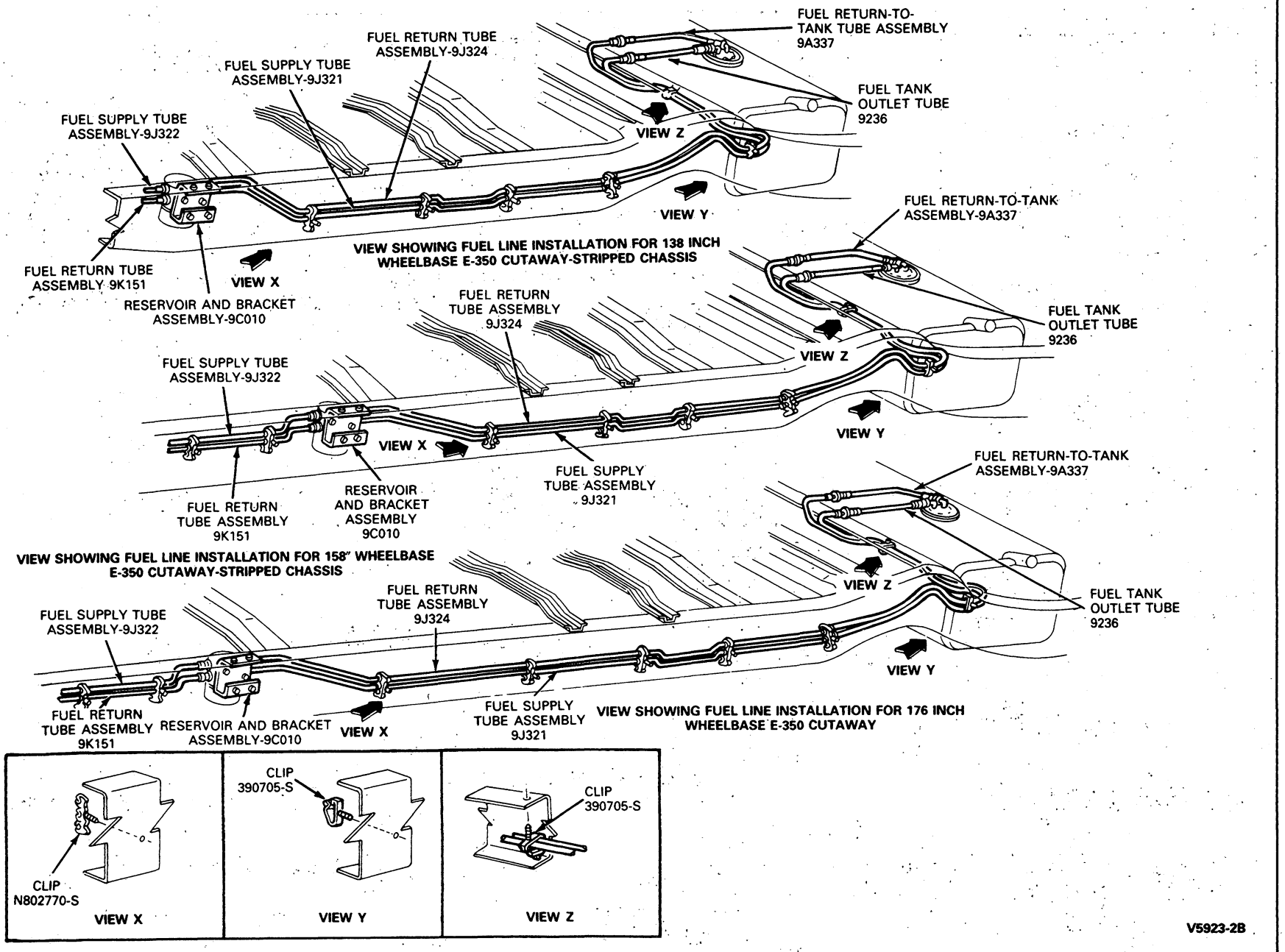


FIG. 48 E-350 R.V. and Commercial Cutaway—Fuel System Installation—(Cont'd.)

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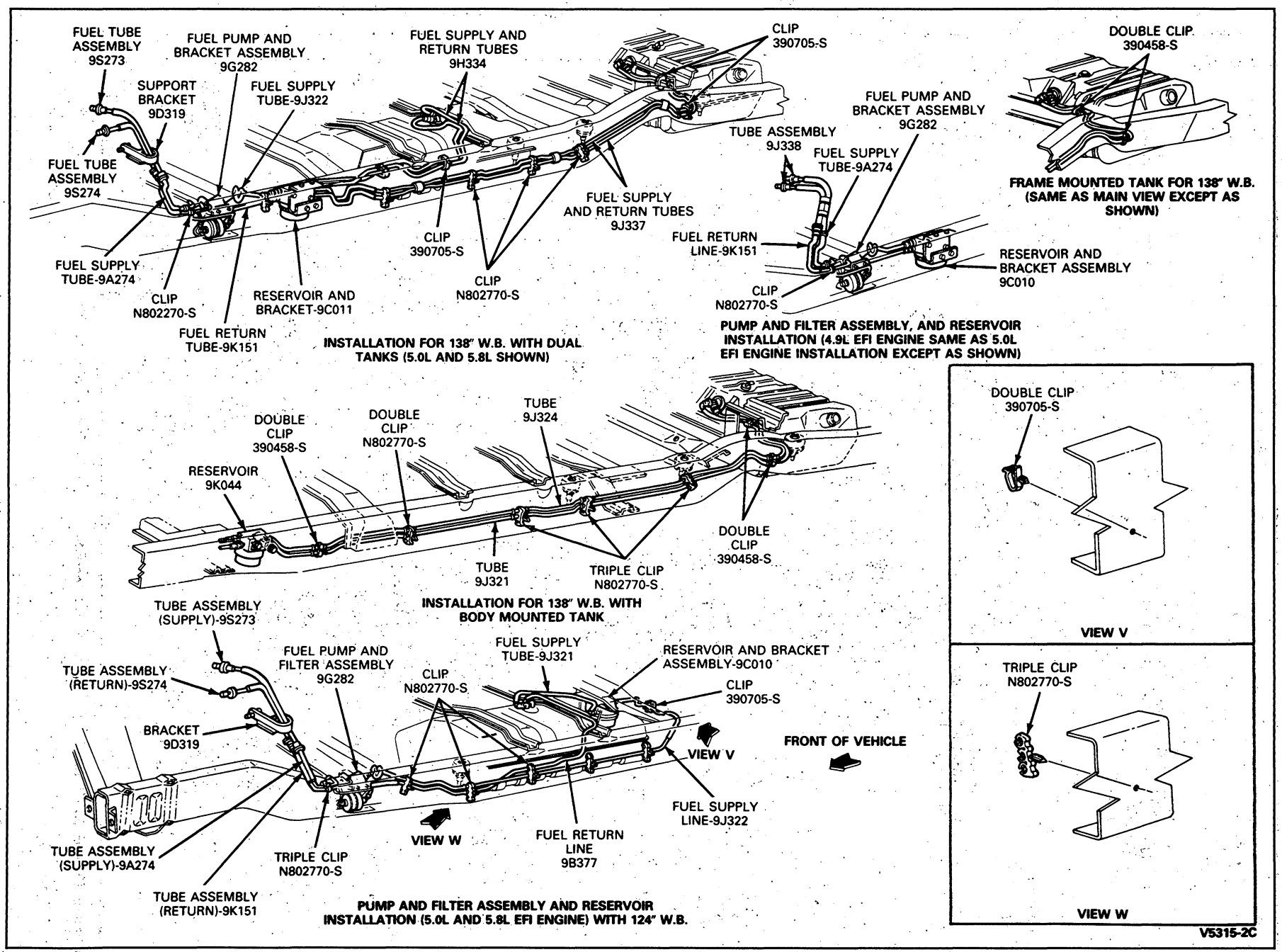


FIG. 48A E-150—E-350 Fuel System—4.9L EFI, 5.0L EFI and 5.8L EFI

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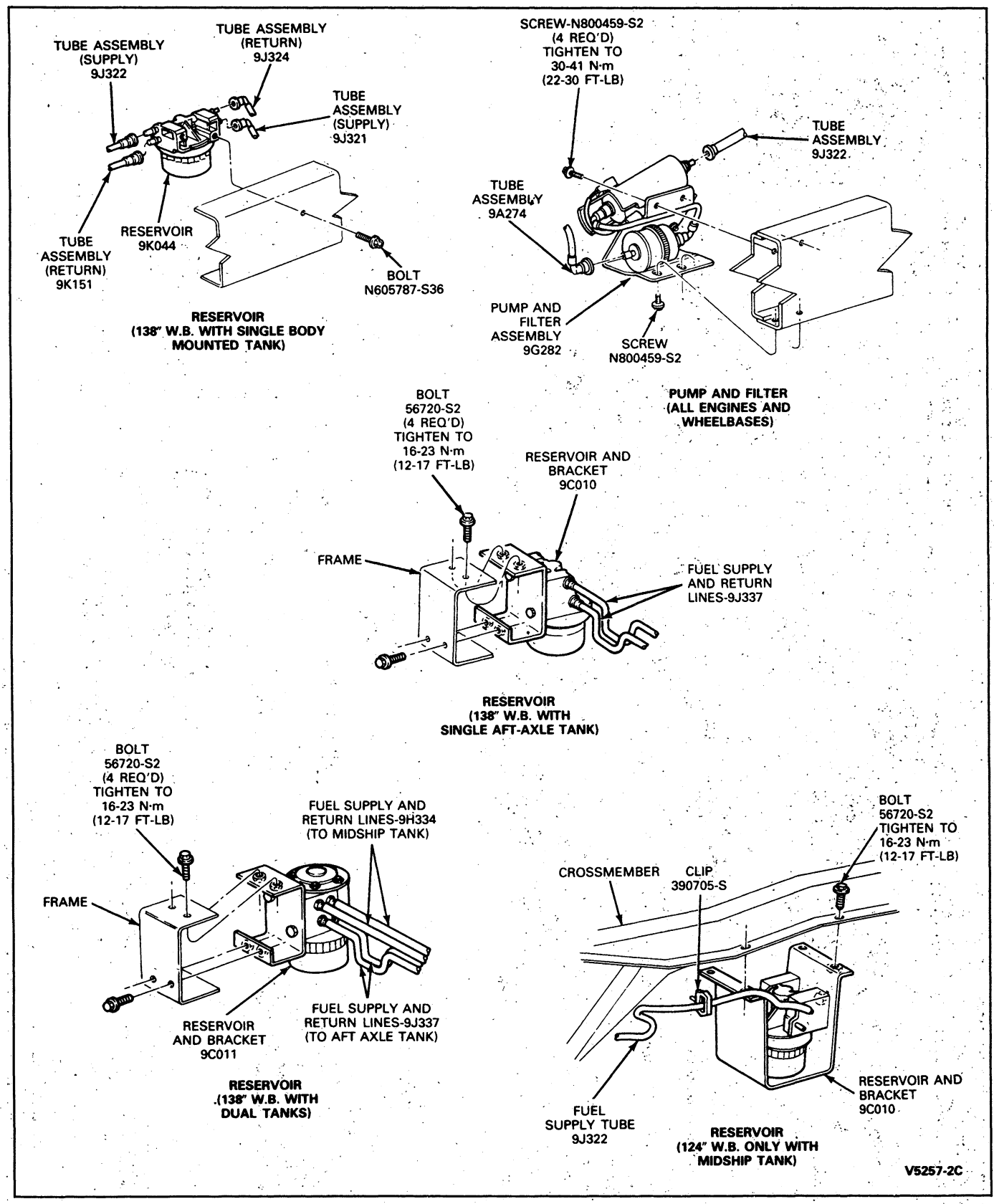


FIG. 49 E-150—E-350 Fuel Reservoir and Pump—4.9L EFI, 5.0L EFI and 5.8L EFI

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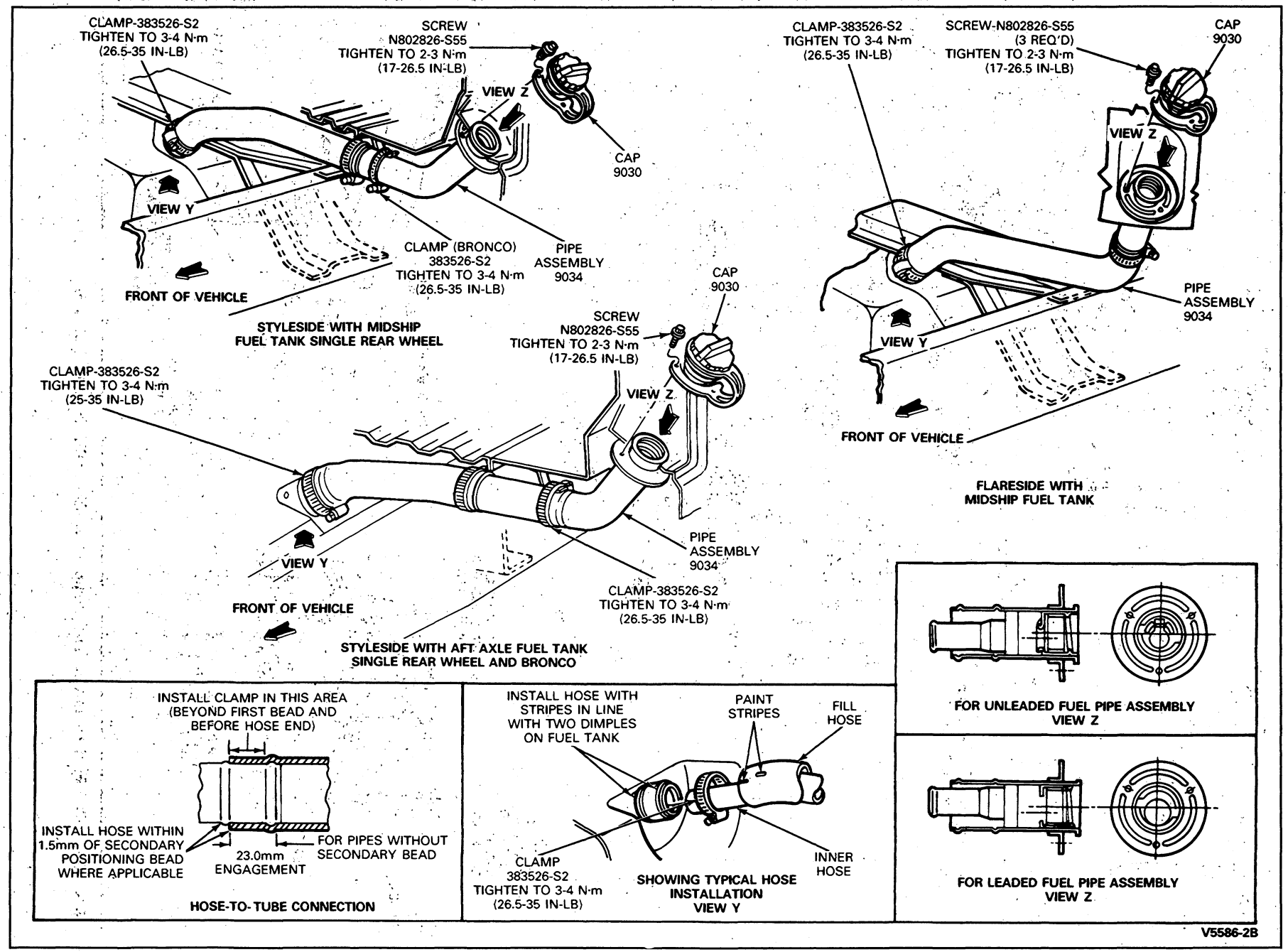


FIG. 50 Fuel Filler System Installation—Single Rear Wheel Styleside F-150—F-350 and Bronco

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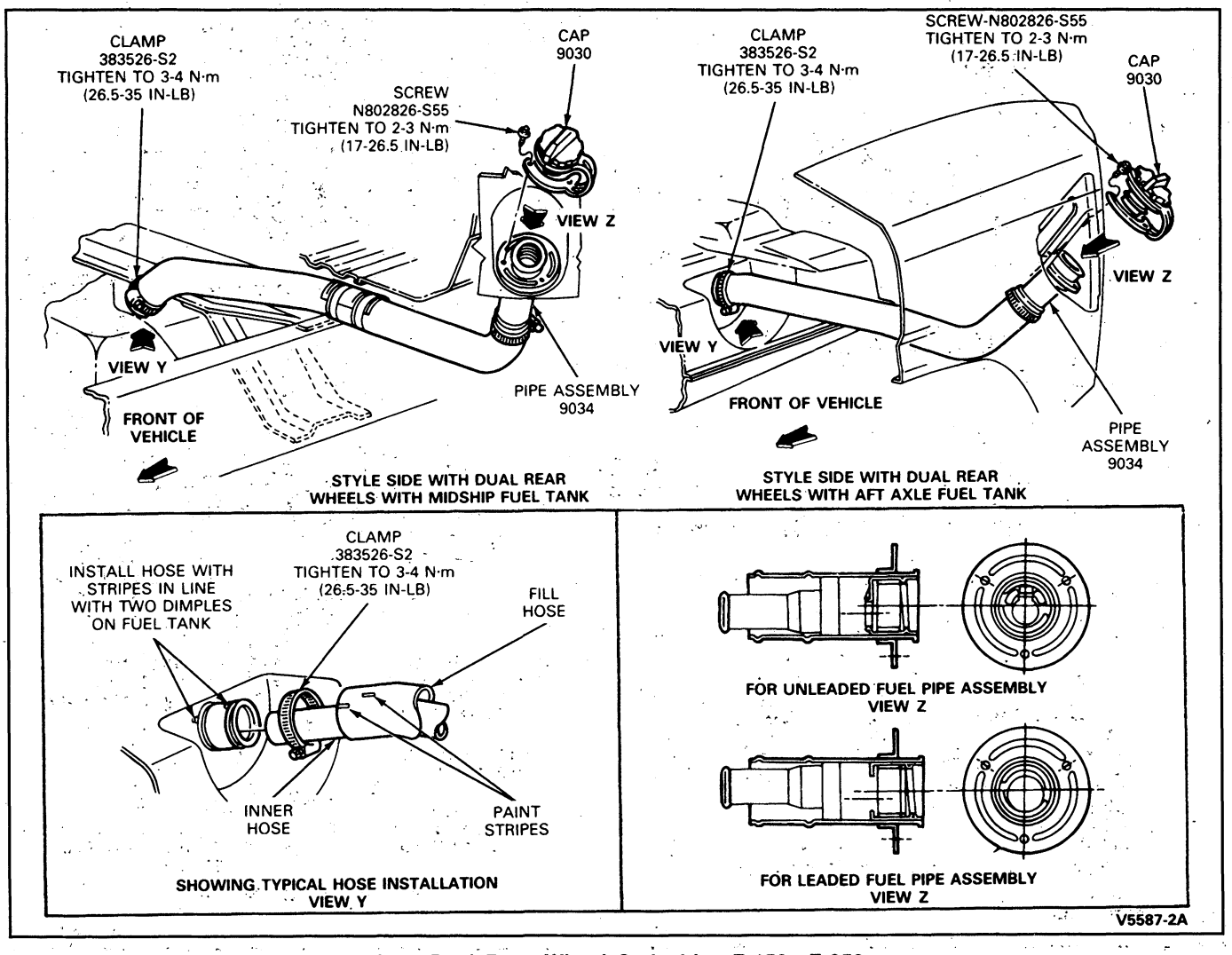


FIG. 51 Fuel Filler System Installation—Dual Rear Wheel Styleside—F-150—F-350

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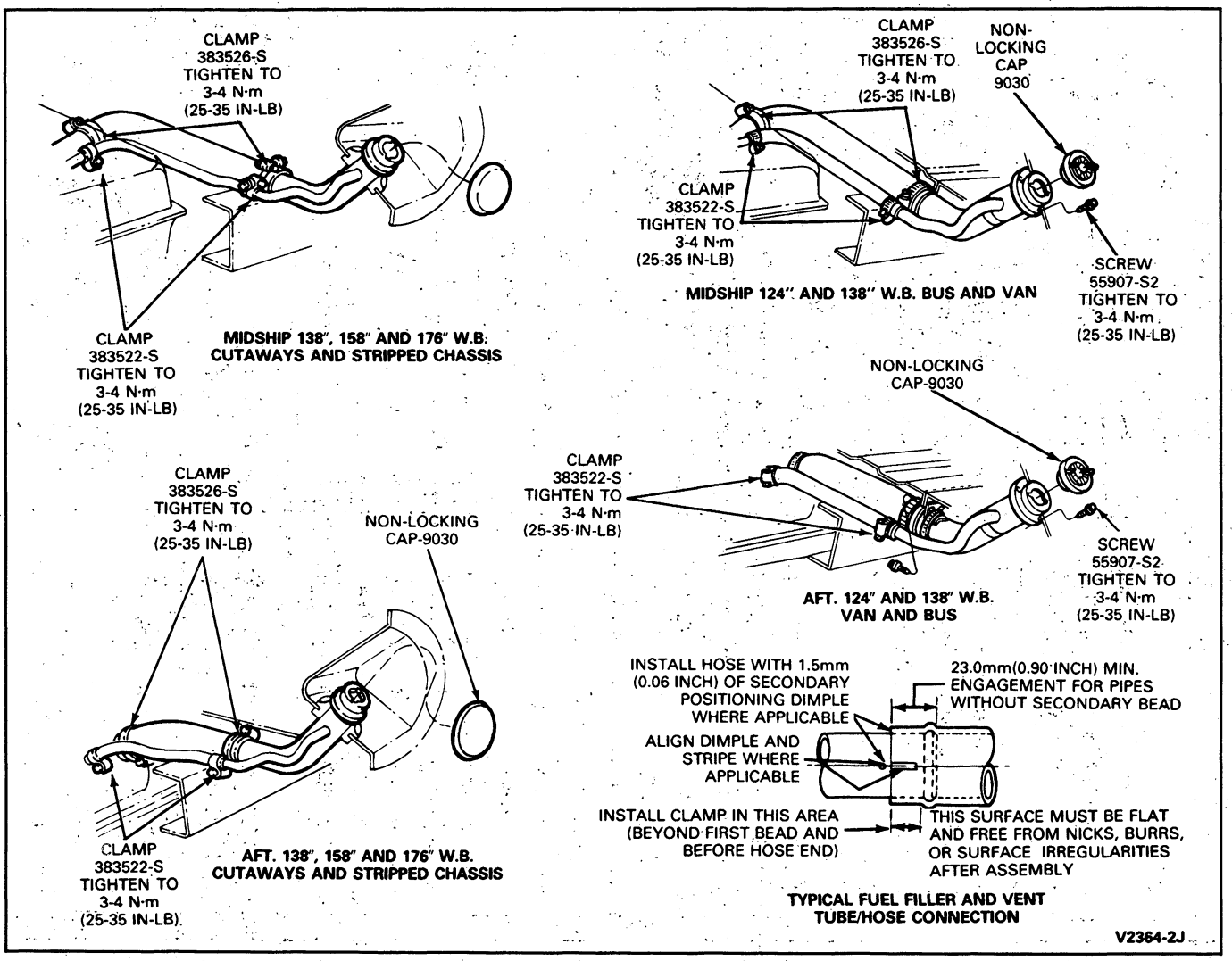


FIG. 52 Fuel Filler System Installation—E-150—E-350 (Midship and Aft Tank) and F-Super Duty Motorhome Stripped Chassis

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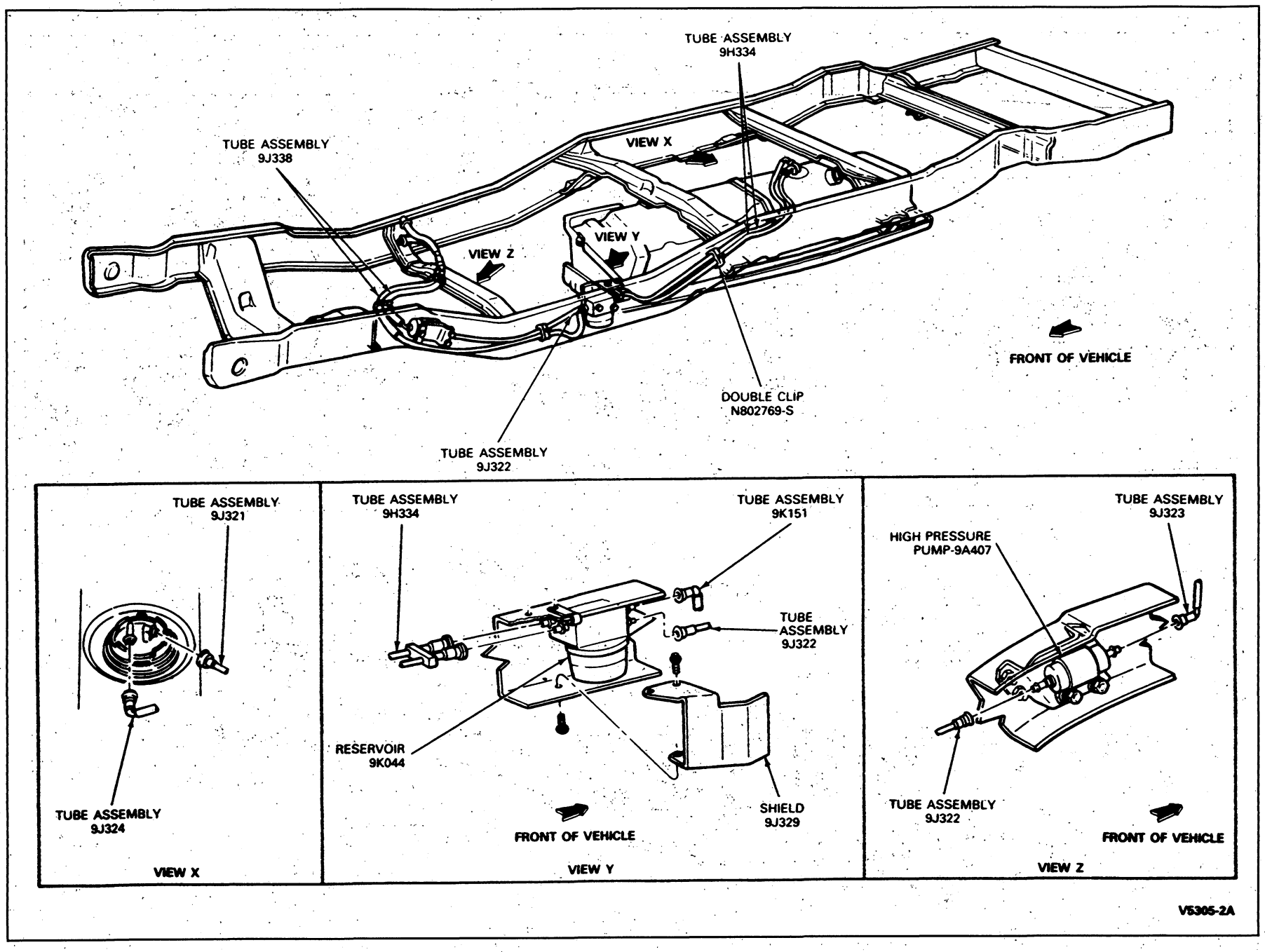


FIG. 53 F-Series All EFI Engine Midship Tank—117 inch and 133 inch WB

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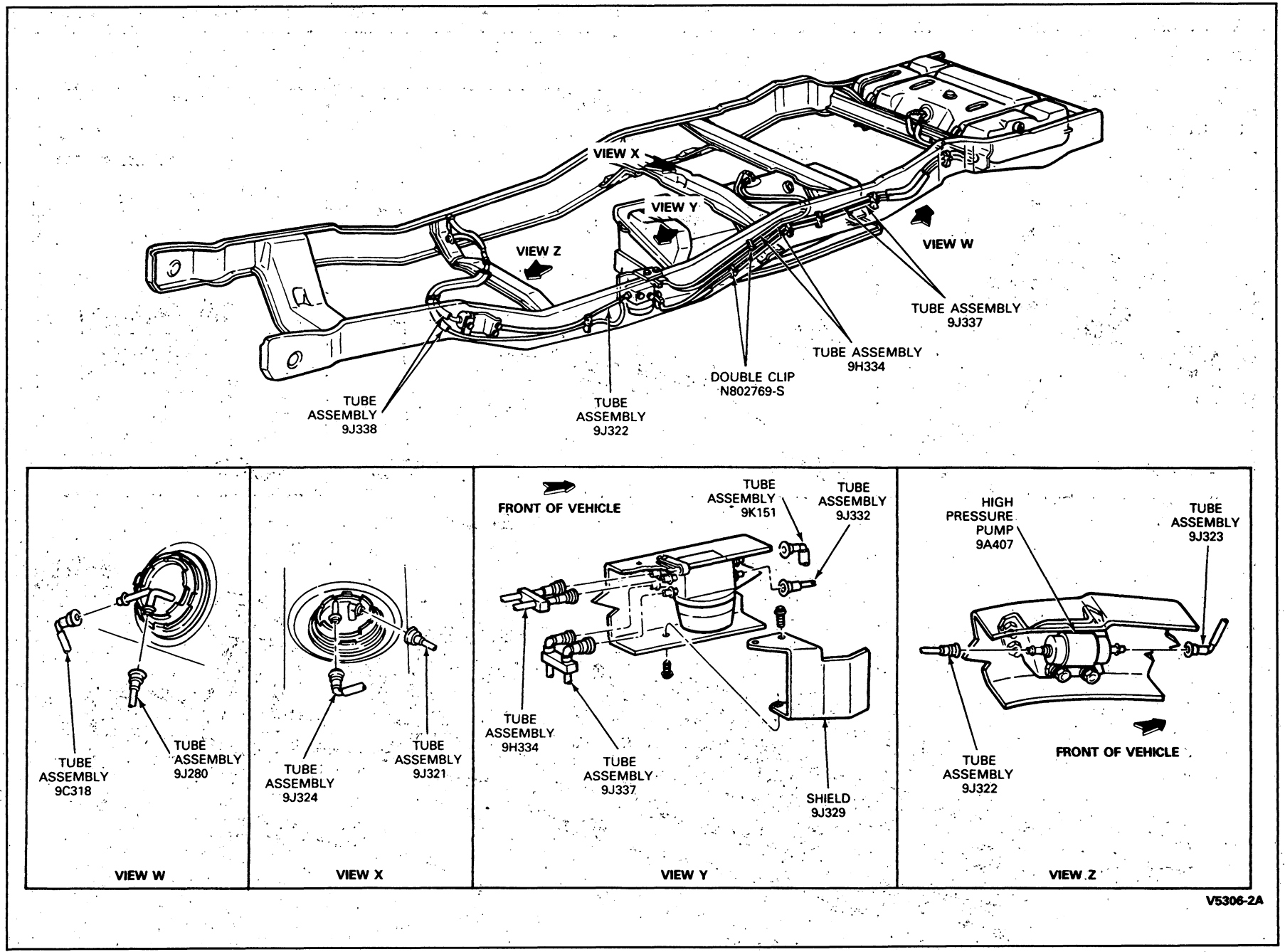


FIG. 54 F-Series All EFI Engine Dual Tanks—117 inch WB, 133 inch WB and 139 inch WB

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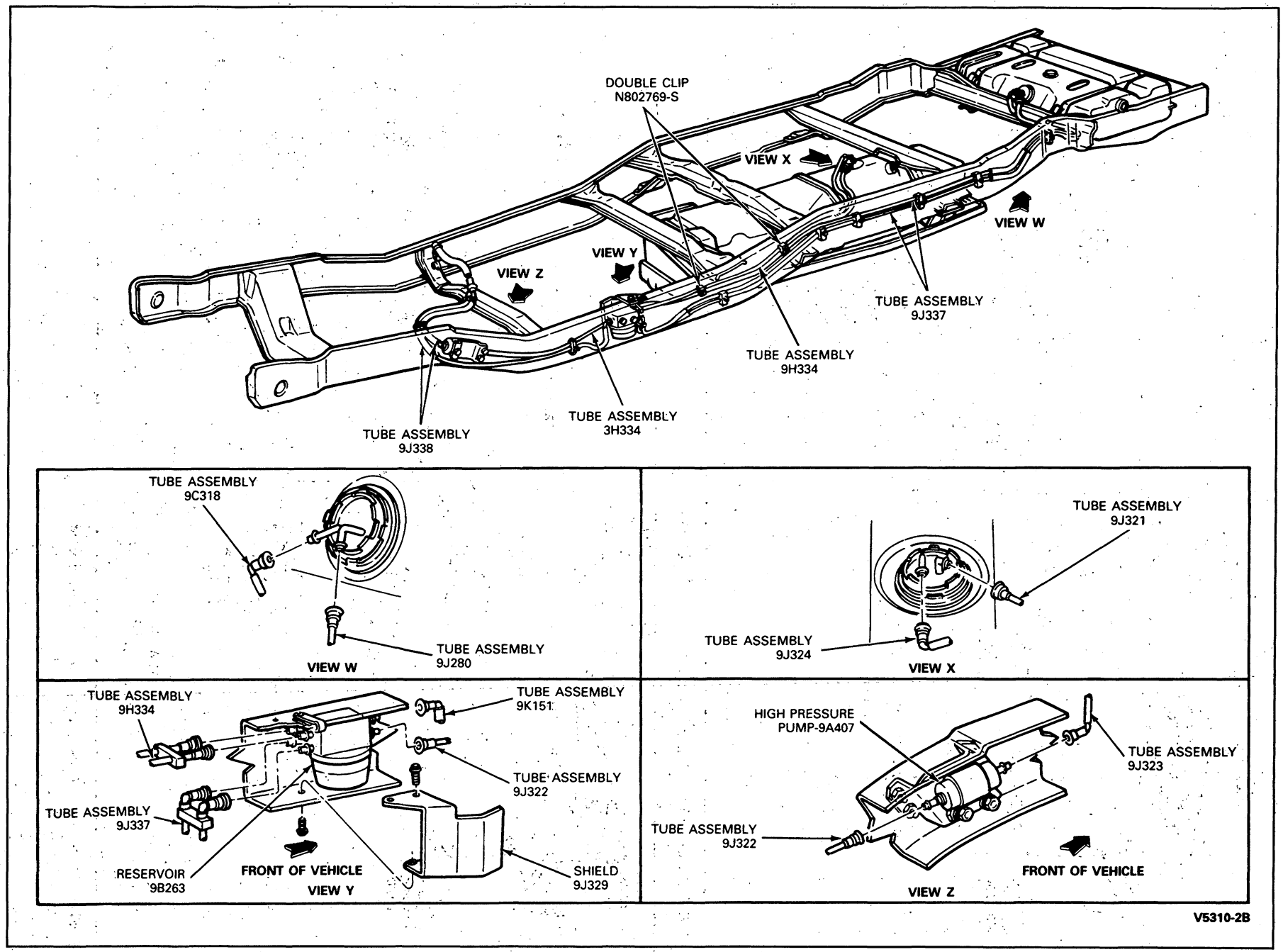


FIG. 55 F-Series All EFI Engine Dual Tanks—155 inch WB

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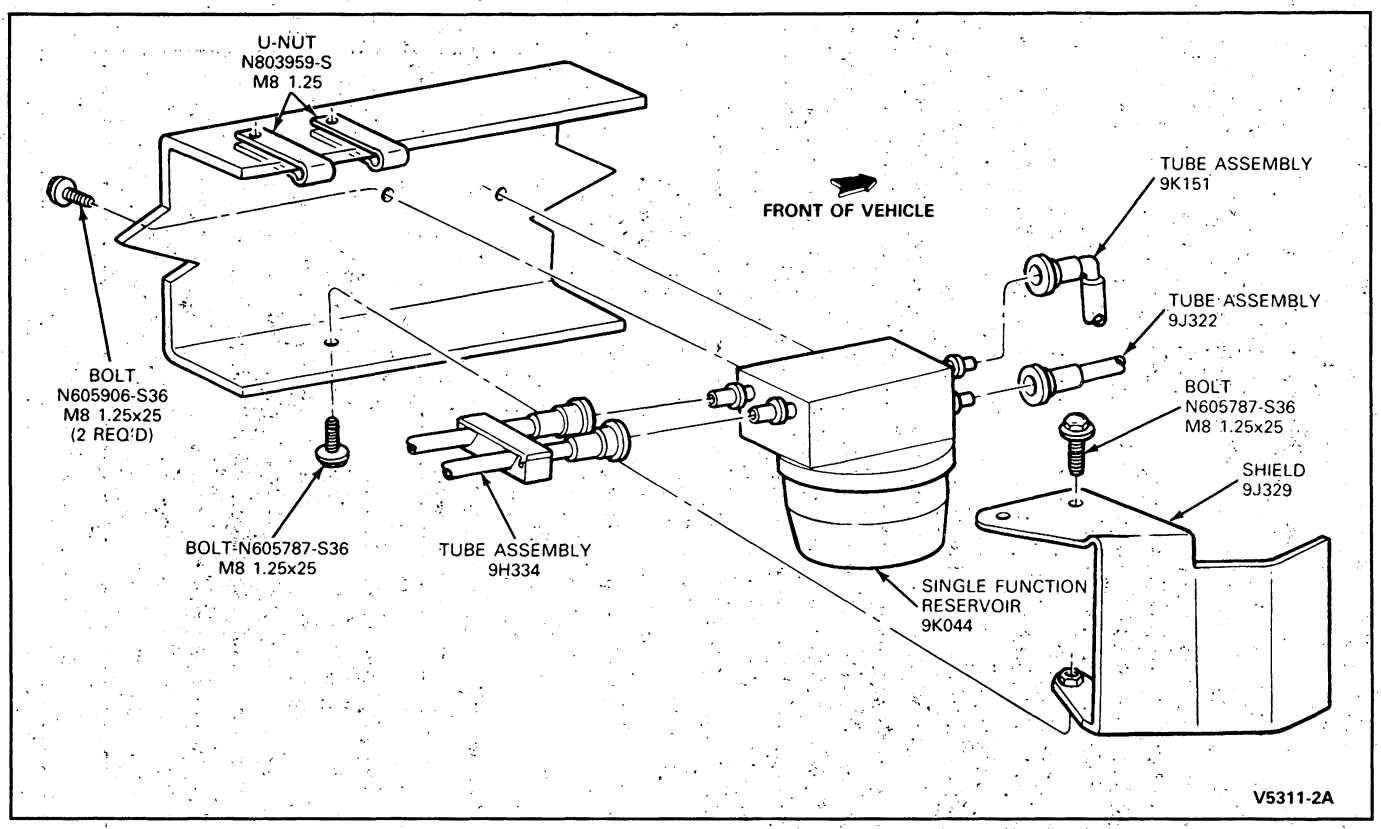


FIG. 56 F-Series Single Function Reservoir with Shield

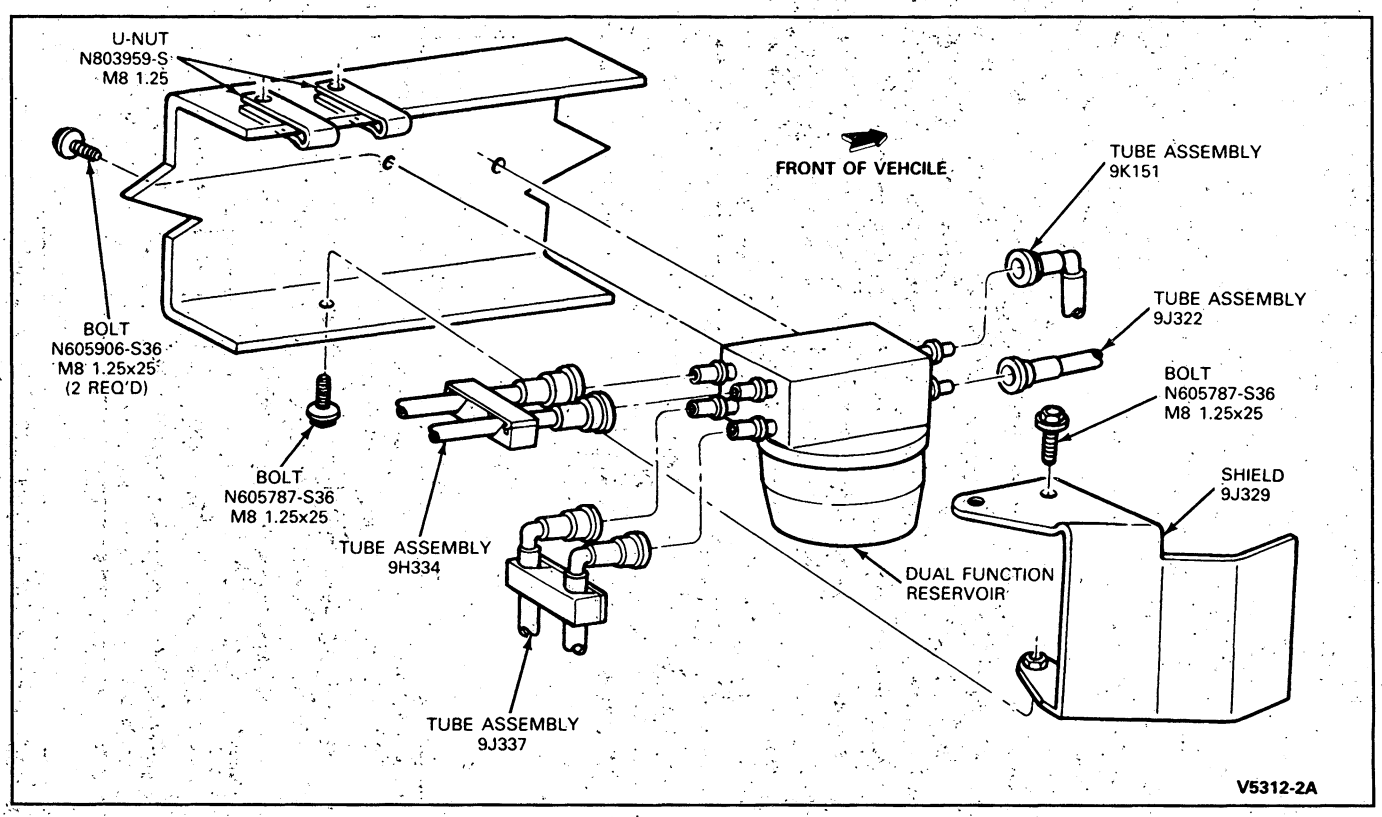


FIG. 57 F-Series Dual Function Reservoir with Shield

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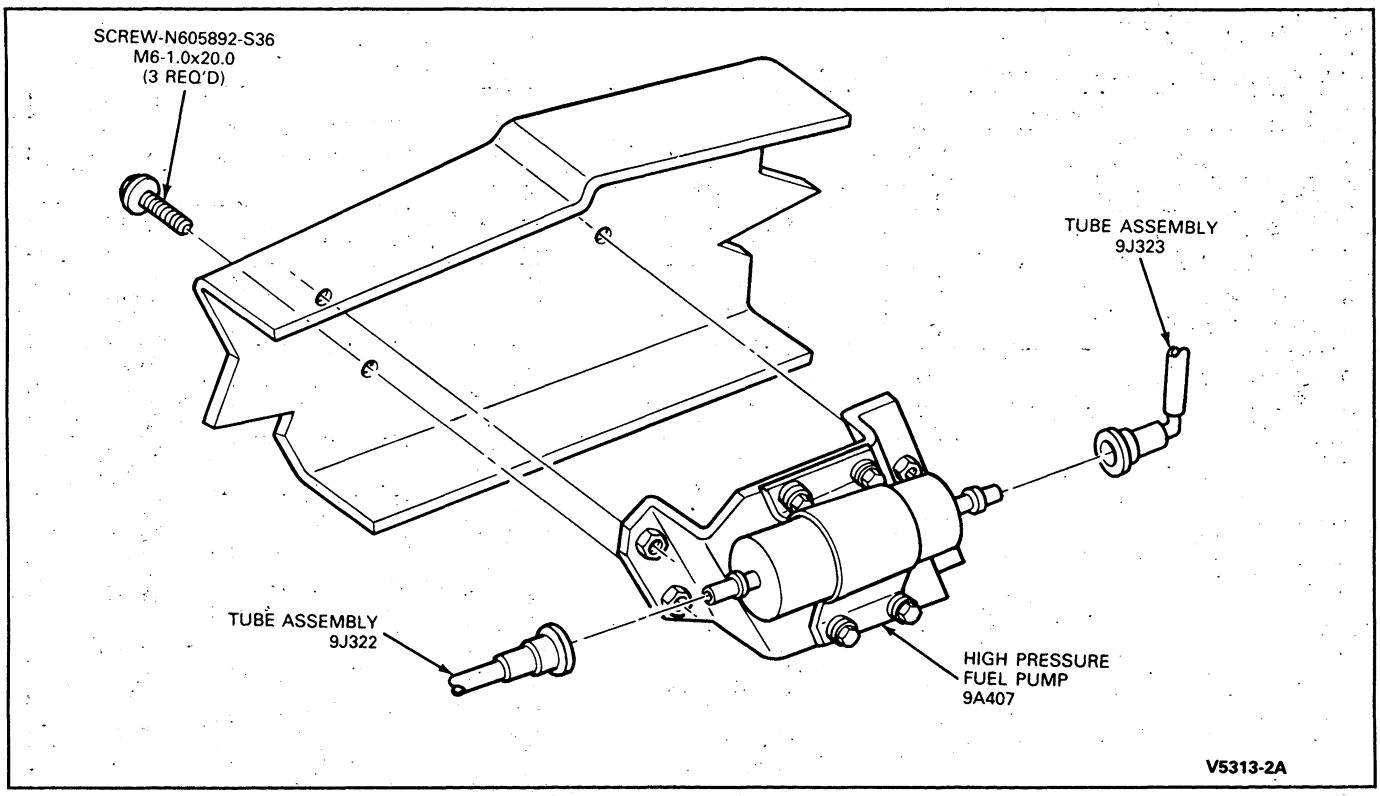


FIG. 58 F-Series High Pressure Pump

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SPECIFICATIONS

STANDARD AND AUXILIARY FUEL TANKS — CAPACITY IN LITERS (GALLONS)

Model					
Series	W.B. mm (In)	Body Style	Location	Fuel Evap.	Advertised Tank Cap. Refill Liters (Gal.)
E-150 Van	3150 (124)	All	Midship	X	68 (18.0)
E-150, 250, 350 Van E-150, 250 Wagon	3505 (138)	All	Aft/Axle Midship②	X X	83 (22) 61 (16)
350 Cutaway & Stripped Chassis⑤	3505 (138) 4018 (158) 4470 (176)	All	Aft/Axle	X	144(38)⑥
E-150, 250, 350 Super Van, Super Wagon	3505 (138)	All	Aft/Axle Midship②	X	83 (22) 61 (16)
Bronco (4x4)	2660 (104.7)	All	Aft/Axle④	X	121 (32)
F-150 (4x2)	2967 (116.8)	Reg. Cab	Midship Aft/Axle②	X X	64 (16.5) 72 (19)
	3378 (133.0)	Reg. Cab	Midship Aft/Axle②	X X	72 (19) 72 (19)
(4x4)	2967 (116.8)	Reg. Cab	Midship① Aft/Axle①②	X X	64 (16.5) 72 (19)
	3378 (133.0)	Reg. Cab	Midship① Aft/Axle①②	X X	72 (19) 72 (19)
(4x2)	3526 (138.8)	Super Cab	Midship Aft/Axle②	X X	64 (16.5) 72 (19)
	3937 (155.0)	Super Cab	Midship Aft/Axle②	X X	72 (19) 72 (19)
(4x4)	3937 (155.0)	Super Cab	Midship① Aft/Axle①②	X X	72 (19) 72 (19)
F-250 (4x2)	3378 (133.0)	Reg. Cab	Midship Aft/Axle②	X X	72 (19) 72 (19)
	3526 (138.8)	Super Cab	Midship Aft/Axle②	X X	64 (16.5) 72 (19)
	3937 (155.0)	Super Cab	Midship Aft/Axle②	X X	72 (19) 72 (19)
(4x4)	3378 (133.0)	Reg. Cab/ W/E4OD Cab Chassis	Midship① Midship⑦ Aft/Axle①②	X X X	72 (19) 87 (23) 72 (19)
	3937 (155.0)	Super Cab	Midship① Aft/Axle①②	X X	72 (19) 72 (19)
F-350 (4x2) and (4x4)	3378 (133.0)	Reg. Cab/ W/E4OD Cab Chassis	Midship Midship⑦ Aft/Axle②	X X X	72 (19) 87 (23) 72 (19)
	3475 (136.8)	Cab Chassis	Midship Aft/Axle③④	X X	72 (19) 72 (19)
	4084 (160.8)	Cab Chassis	Midship Aft/Axle③④	X X	72 (19) 72 (19)
	3937 (155.0)	Crew Cab	Midship Aft/Axle②	X X	72 (19) 72 (19)
F-Super Duty	3475 (136.8)	Chassis Cab	Midship Aft/Axle②	X X	72 (19) 72 (19)
	4085 (160.8)	Chassis Cab	Aft/Axle② Midship	X X	72 (19) 72 (19)
F-Super Duty Motor Home Chassis	4521 (178)	Stripped Chassis	Aft/Axle⑤	X	284 (75)
	5283 (208)	Stripped Chassis	Aft/Axle⑤	X	284 (75)

①R.P.O. Skid Plate Available w/4x4 Models.
②Steel Auxiliary Tank
③Plastic Auxiliary
④Standard Skid Plate
⑤15 Liters (4 Gal.) Throwaway Standard on RV Chassis/RV Cutaway, Commercial Cutaway, and Commercial Chassis.
⑥Available on Cutaway and stripped chassis only.
⑦Standard Plastic Tank

CV2366-2L

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SPECIAL SERVICE TOOLS

Tool	Description
T63P-9171-A	Keystone Clamp Pliers
T74P-9275-A	Fuel Tank Sender Wrench
D87L-9280-A	Spring-Lock Coupling Tool - 3/8 inch
D87L-9280-B	Spring-Lock Coupling Tool - 1/2 inch
T83P-19623-C	Spring Lock Coupling Tools - 5/8 in.
Rotunda Equipment	
034-00002	Fuel Storage Tanker
014-00702	Vacuum/Pressure Tester
007-00001	Digital Volt-Ohm Meter
134-00001	Fuel Line Installation Tool

CV3657-1F

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SECTION 24-51 Fuel Filters—Gasoline Engines

SUBJECT	PAGE
DESCRIPTION	24-51-1
REMOVAL AND INSTALLATION	
Econoline EFI In-Line Fuel Filter	24-51-1
REMOVAL AND INSTALLATION (Cont'd)	
Fuel Filter—In-Line Type	24-51-1
VEHICLE APPLICATION	24-51-1

VEHICLE APPLICATION

All Models.

DESCRIPTION

The in-line fuel filter provides filtration to protect the small metering orifices of the injector nozzles. The filter is located on the frame rail between the frame mounted high pressure pump and engine.

NOTE: The filter should last the life of the vehicle under normal driving conditions. If the filter does need to be replaced, proceed as follows:

WARNING: NO SMOKING OR OPEN FLAME OF ANY TYPE SHOULD BE PRESENT WHEN WORKING NEAR FUEL OR FUEL VAPOR.

REMOVAL AND INSTALLATION

Fuel Filter—In-Line Type—4.9L EFI, 5.0L EFI, 5.8L EFI and 7.5L EFI Engines

Refer to Figs. 1 and 2.

Removal

CAUTION: If the fuel filter is being serviced with the rear of the vehicle higher than the front, or if the tank is pressurized, fuel leakage or siphoning from the tank fuel lines could occur. To prevent this condition, maintain the vehicle front end at or above the level of the rear of vehicle. Also, relieve tank pressure by loosening the fuel fill cap. Cap should be retightened after pressure is relieved. If vehicle is warm, change the fuel filter before the pressure rebuilds.

Econoline EFI In-Line Fuel Filter

Removal

1. Shut engine off. De-pressurize fuel system. Refer to Section 24-50 Fuel Tanks and Lines and Fuel Evaporative Emission Control System. Use caution to prevent combustion from fuel spillage.
2. Raise vehicle on hoist. Refer to Volume F Pre-Delivery manual, Section 50-04, Hoisting and Jacking.
3. Loosen screw clamp so that filter slides rearward easily.
4. Remove push connect fittings at both ends of the filter. Refer to Section 24-50 Fuel Tanks and Lines and Fuel Evaporative Emission Control System. Install new retainer clips in each push connect fitting.

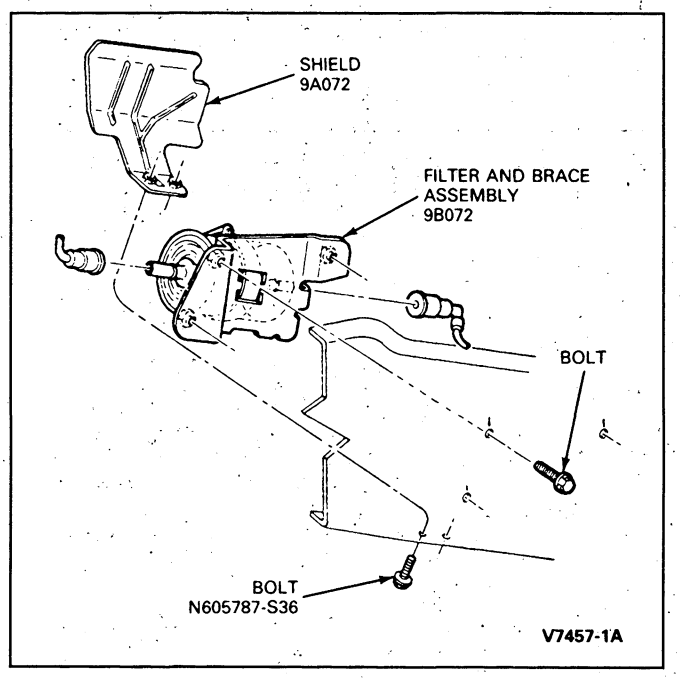


FIG. 1 Fuel Filter—In-Line Type—4.9L EFI, 5.0L EFI, 5.8L EFI and 7.5L EFI Engines—F-Series Shown Bronco Similar

5. Remove fuel filter from metal bracket by rotating the -9A322- fuel line, being careful not to kink the fuel line, and sliding the filter rearward.

Installation

Note that the direction of the flow arrow points to the tab of the bracket against which the filter rests (Fig. 1).

1. Place filter into the bracket with flow arrow pointing toward tab of the bracket. Slide filter forward until it rests against tab of the bracket (Fig. 1).
2. Tighten retaining screw of the screw clamp to 1.8-2.8 N·m (1.3-2.1 ft-lb).
3. Install push-connect fittings onto filter ends. Refer to Section 24-50 Fuel Tanks and Lines and Fuel Evaporative Emission Control System.
4. Turn ignition switch from OFF to RUN position several times, without starting engine. Check for fuel leaks.
5. Lower vehicle.

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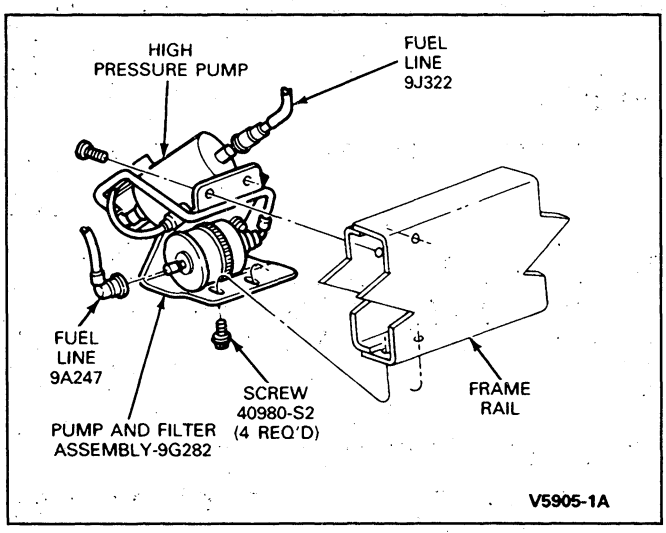


FIG. 2 Fuel Filter—In-Line Type—4.9L EFI, 5.0L EFI, 5.8L EFI and 7.5L EFI Engines—E-Series

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SECTION 24-60 Throttle Linkage

SUBJECT	PAGE
ADJUSTMENTS	
Non-Automatic Overdrive Transmission	24-60-1
Throttle Valve (TV) Control Linkage System Automatic Overdrive Transmission	24-60-1
DIAGNOSIS	24-60-9
REMOVAL AND INSTALLATION	
Except 5.0L EFI and 5.8 EFI Engines	24-60-1
5.0L EFI and 5.8L EFI Engines	24-60-1
VEHICLE APPLICATION	24-60-1

VEHICLE APPLICATION

All Models.

ADJUSTMENTS

Non-Automatic Overdrive Transmission

Instructions for adjusting throttle linkages used on all gasoline-engine trucks are contained in Figs. 1 through 5. Refer to the appropriate figure for procedures.

Whenever possible, the engine should be at operating temperature when throttle linkage adjustments are made.

CAUTION: Throttle return springs must be installed as indicated in the illustrations and instructions in order to ensure proper accelerator return. After adjustment, ensure that accelerator returns to idle on slow release of foot pressure, without binding or dragging.

Throttle Valve (TV) Control Linkage System Automatic Overdrive Transmission

Refer to Section 17-20 Automatic Overdrive Transmission for adjustment procedure.

REMOVAL AND INSTALLATION

Except 5.0L EFI and 5.8 EFI Engines

Linkage disconnect points are shown in Figs. 1 through 2A. Installation specifications of major parts are also given.

Be sure to install throttle return springs as shown on the illustrations.

5.0L EFI and 5.8L EFI Engines

Removal

Refer to Figs. 4 and 5.

1. Remove cable from pedal shaft.
2. Remove cable from dash panel.
3. For F-series vehicles, remove the two screws retaining shield to the accelerator cable bracket. Remove the shield.
4. Remove cable from mounting bracket.
5. Remove cable from ball stud.
6. Remove three screws retaining pedal shaft to dash.
7. Remove two screws retaining bracket to intake manifold.

Installation

1. Install two screws retaining bracket to intake manifold.
2. Install three screws retaining pedal shaft to dash.
3. Install cable to ball stud.
4. Install cable to mounting bracket.
5. Install two screws retaining cable to dash panel.
6. Install cable to pedal shaft.
7. For F-series vehicles, install two screws retaining shield to accelerator cable bracket.

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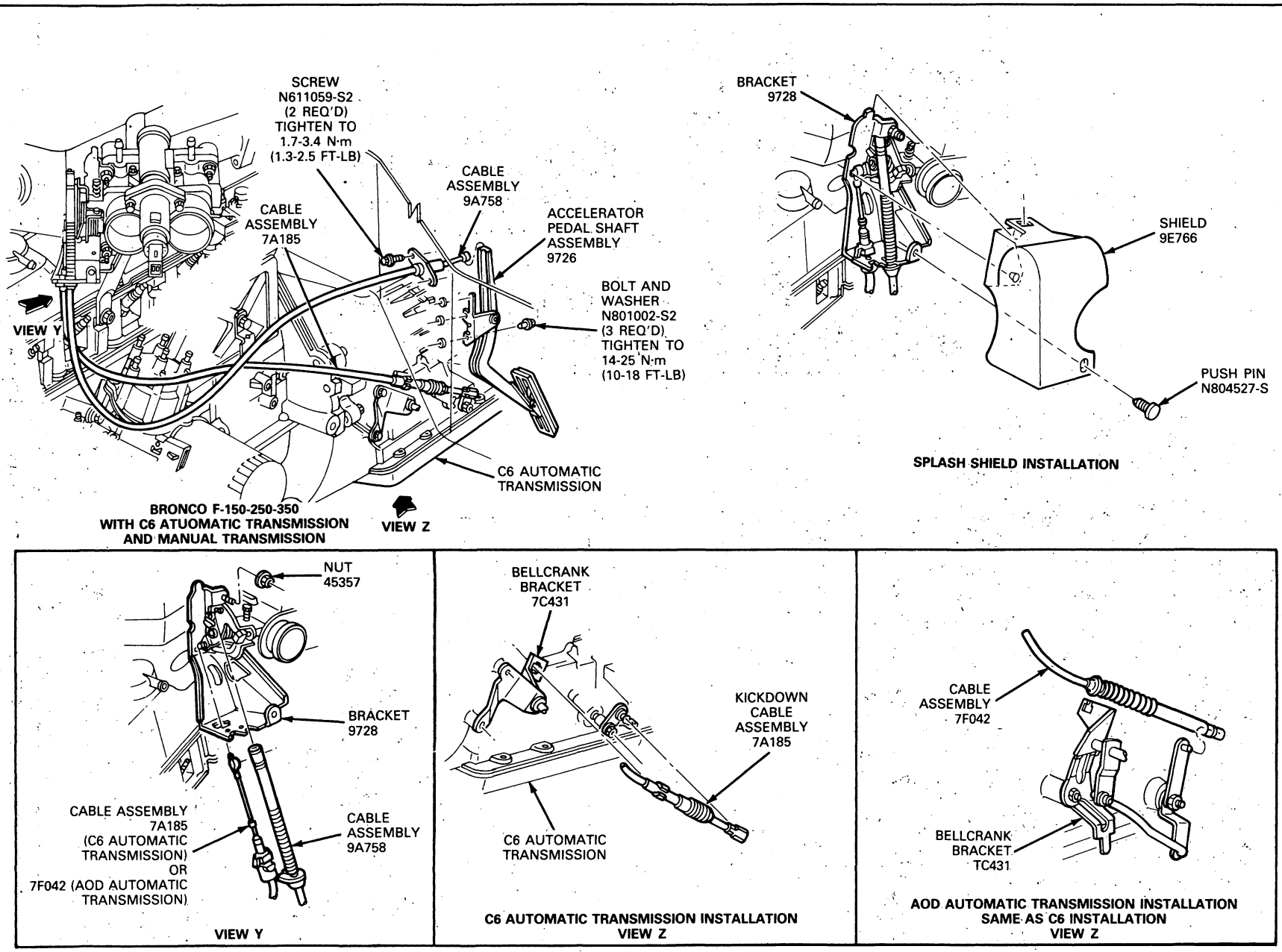
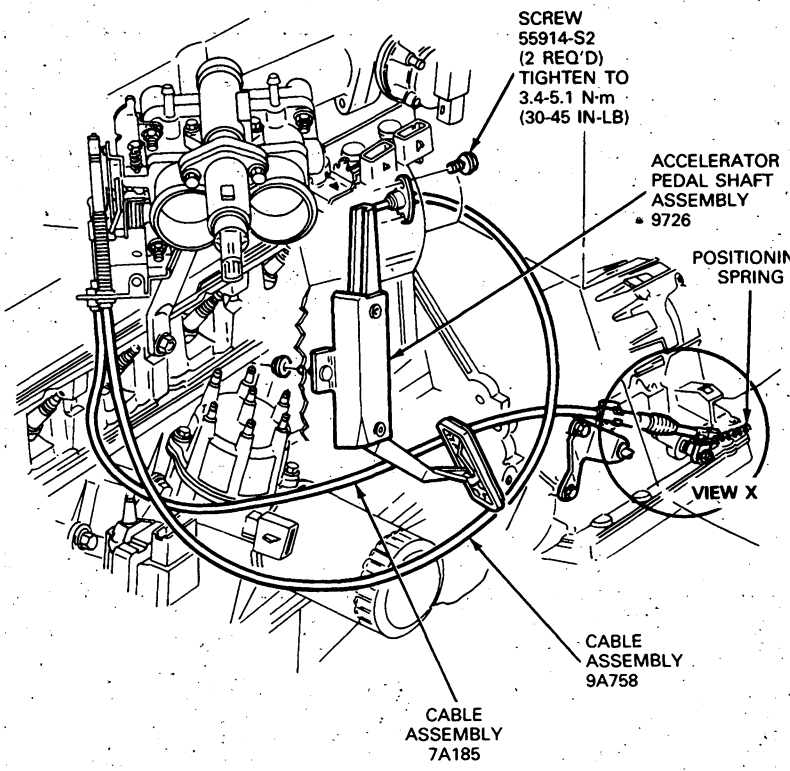


FIG. 1 Throttle Linkage—F-150—F-350, E-150—E-250 and Bronco with 4.9L EFI Engine

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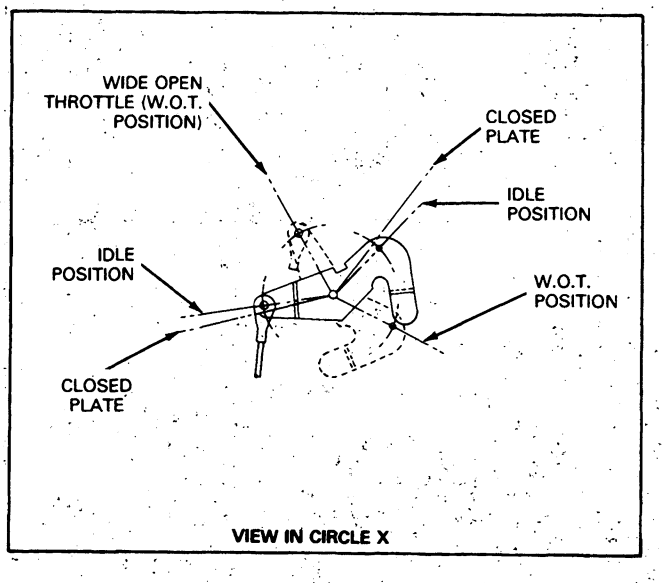


C6 AUTOMATIC TRANSMISSION KICKDOWN CABLE INSTALLATION AND ADJUSTMENT

1. SELECT KICKDOWN CABLE. INSERT CONDUIT FITTING INTO ENGINE BRACKET AND SLIDE CABLE END FITTING ONTO NAILHEAD STUD ON THROTTLE LEVER. ENSURE THAT THROW-AWAY RED SPACER IS SECURED ON CABLE END FITTING. IF SPACER IS MISSING, REUSE A DISCARDED ONE.
2. ROUTE CABLE DOWN TO TRANSMISSION AND INSERT CONDUIT FITTING INTO BRACKET, THEN SNAP CABLE END ONTO BALL STUD ON TRANSMISSION LEVER.
3. RATCHET CABLE ADJUSTING MECHANISM TO CORRECT SETTING BY ROTATING TO WIDE OPEN THROTTLE POSITION, WITH TOOL NO. 52F-23415 OR BY HAND. REMOVE RED SPACER.

AOD AUTOMATIC TRANSMISSION TV CABLE INSTALLATION AND ADJUSTMENT

1. CHECK TO ENSURE ENGINE IS OFF OF HIGH IDLE SPEED BEFORE SETTING TRANSMISSION TV.
2. SELECT TV CABLE. INSERT CONDUIT FITTING INTO ENGINE BRACKET. SLIDE CABLE END FITTING OVER NAILHEAD STUD ON THROTTLE LEVER.
3. ROUTE CABLE DOWN TO TRANSMISSION. INSERT CONDUIT FITTING INTO BRACKET ON TRANSMISSION. SNAP CABLE END OVER BALL STUD ON TRANSMISSION LEVER.
4. CONNECT A POSITIONING SPRING (NOT SUPPLIED WITH TRANSMISSION) BETWEEN TV LEVER BALL STUD AND REAR OF TRANSMISSION CAGE. THE SPRING SHOULD BE OF SUFFICIENT STRENGTH TO ENSURE THAT THE TV LEVER IS HELD IN THE FULL CLOCKWISE POSITION.
5. PUSH DOWN LOCKING TAB AT ENGINE END OF CONDUIT FITTING TO LOCK CONDUIT AT CORRECT LENGTH. TAB TO BE FLUSH WITH CIRCULAR PROFILE OF FITTING.
6. REMOVE POSITIONING SPRING, HOLDING TRANSMISSION TV LEVER.



VIEW IN CIRCLE X

E-150-250 INSTALLATION WITH C6 AUTOMATIC TRANSMISSION
SAME AS F-150-250-350 INSTALLATION EXCEPT AS SHOWN

V5623-2B

FIG. 1A Throttle Linkage—F-150—F-350, E-150—E-250 and Bronco with 4.9L EFI Engine (Cont.)

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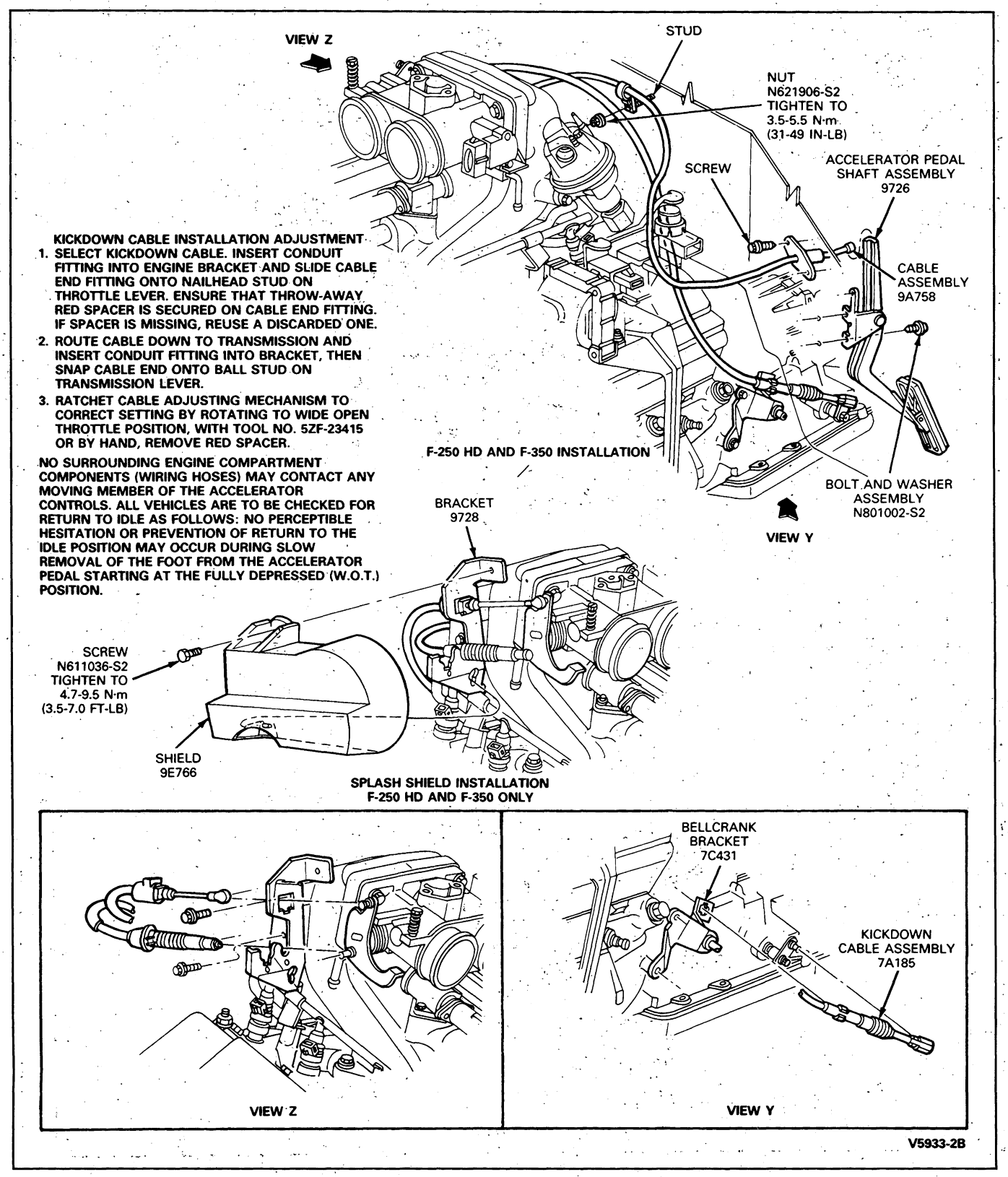


FIG. 2 Throttle Linkage—F-250HD—F-350—E-250HD—E-350 and F-Super Duty Chassis Cab with 7.5L EFI Engine

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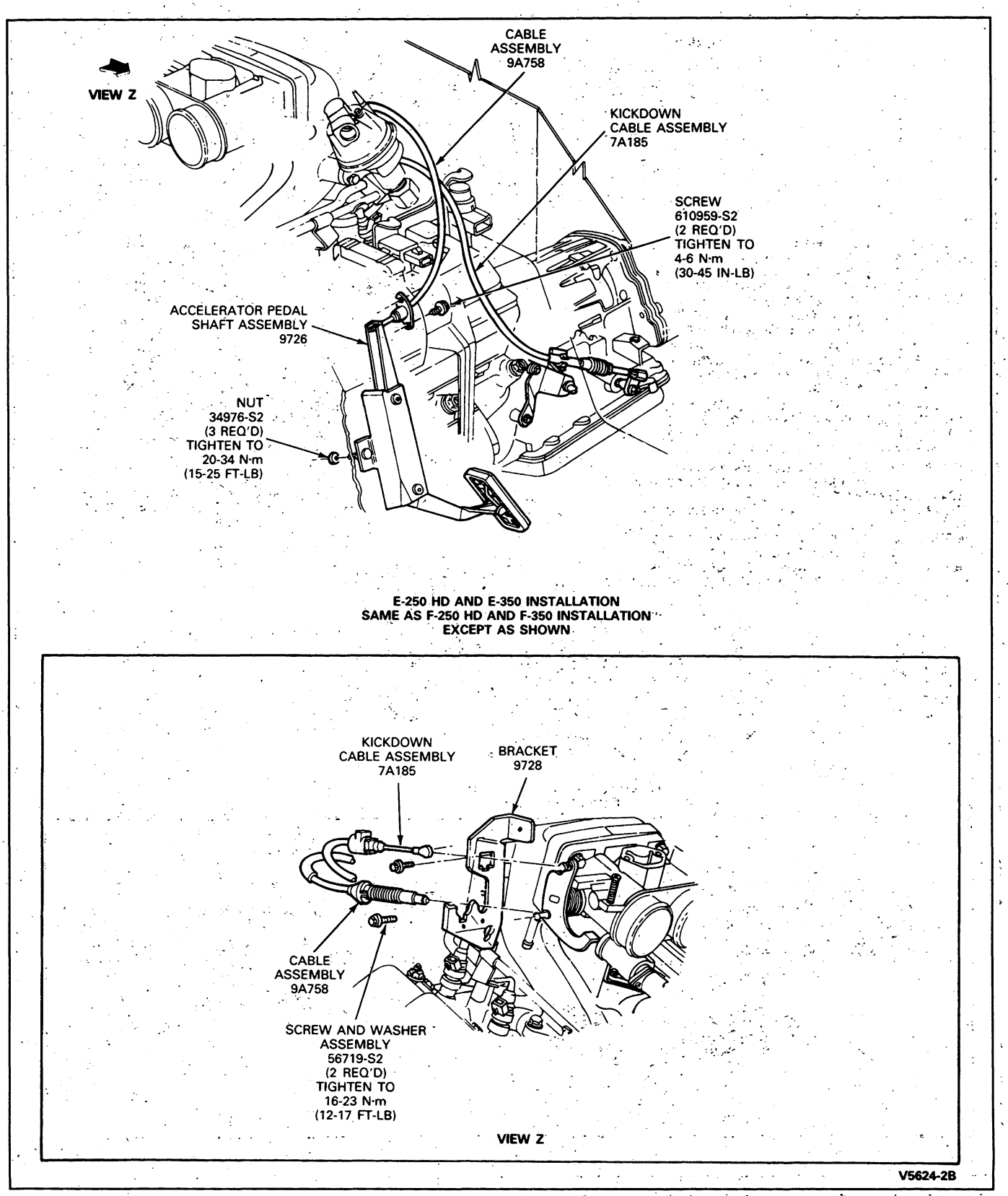


FIG. 2A Throttle Linkage—F-250HD—F-350 and E-250HD—E-350 with 7.5L EFI Engine

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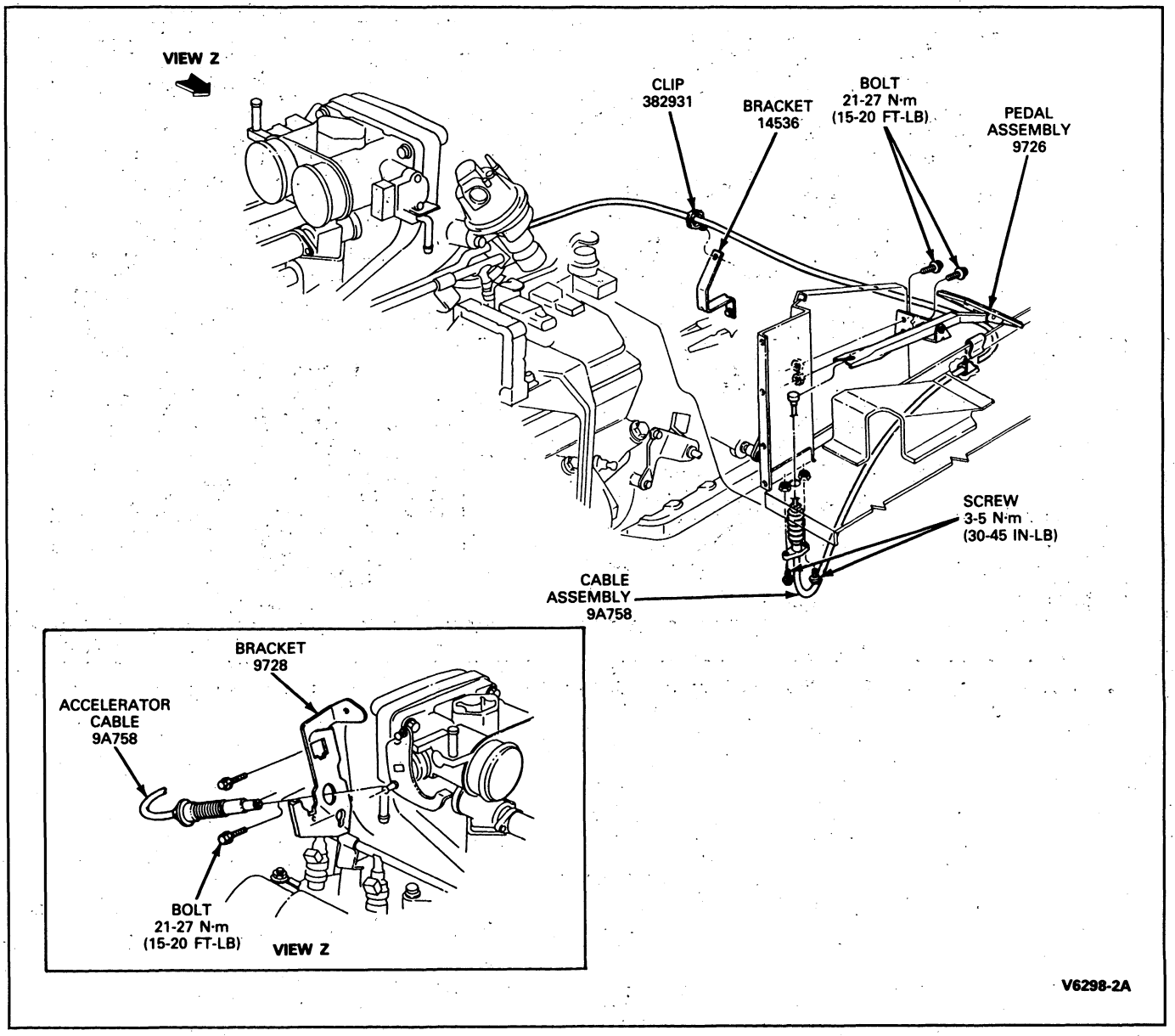


FIG. 3 Throttle Linkage—F-Super Duty Motor Home Chassis Vehicles with 7.5L EFI Engine

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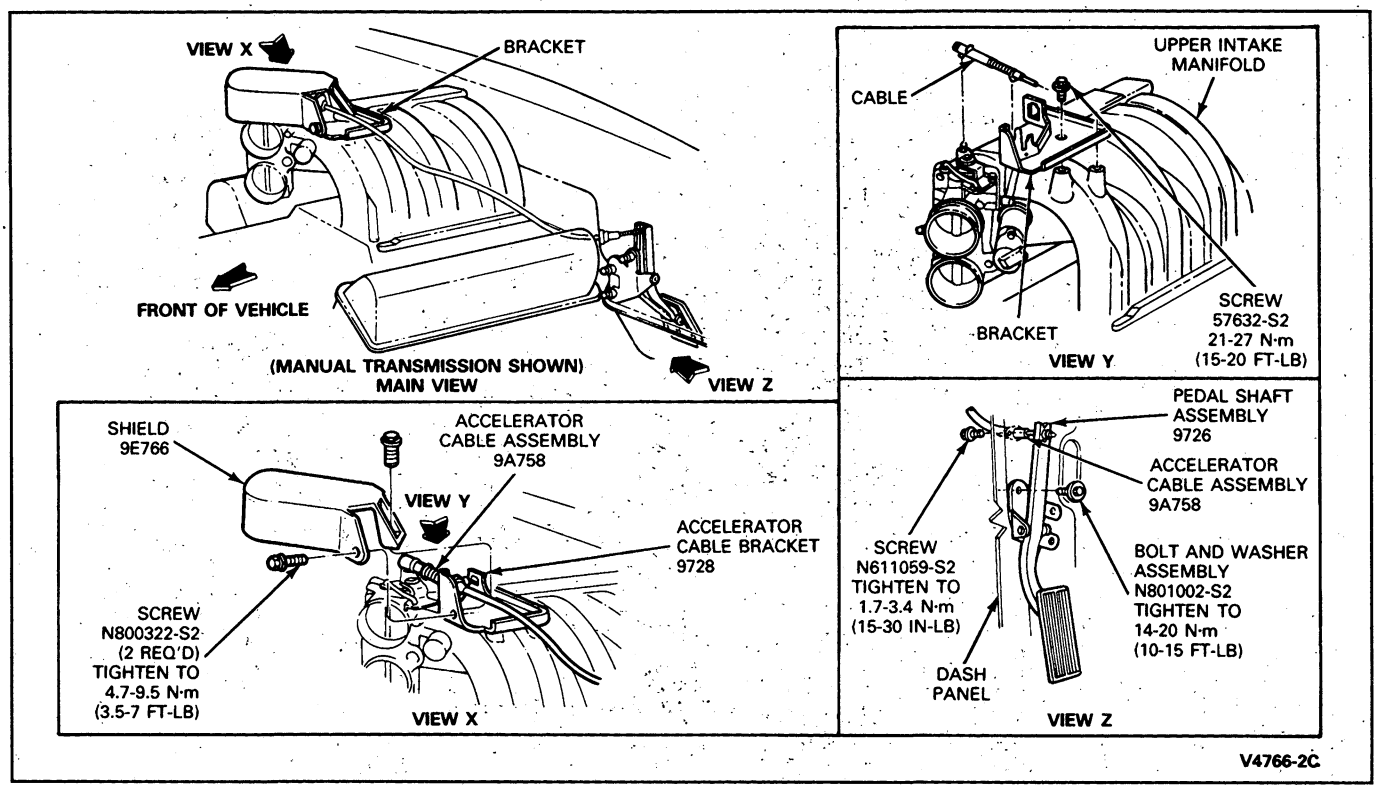


FIG. 4 Throttle Linkage—F-150—F-350 and Bronco with 5.0L (302 CID) EFI or 5.8L (351 CID) Engines

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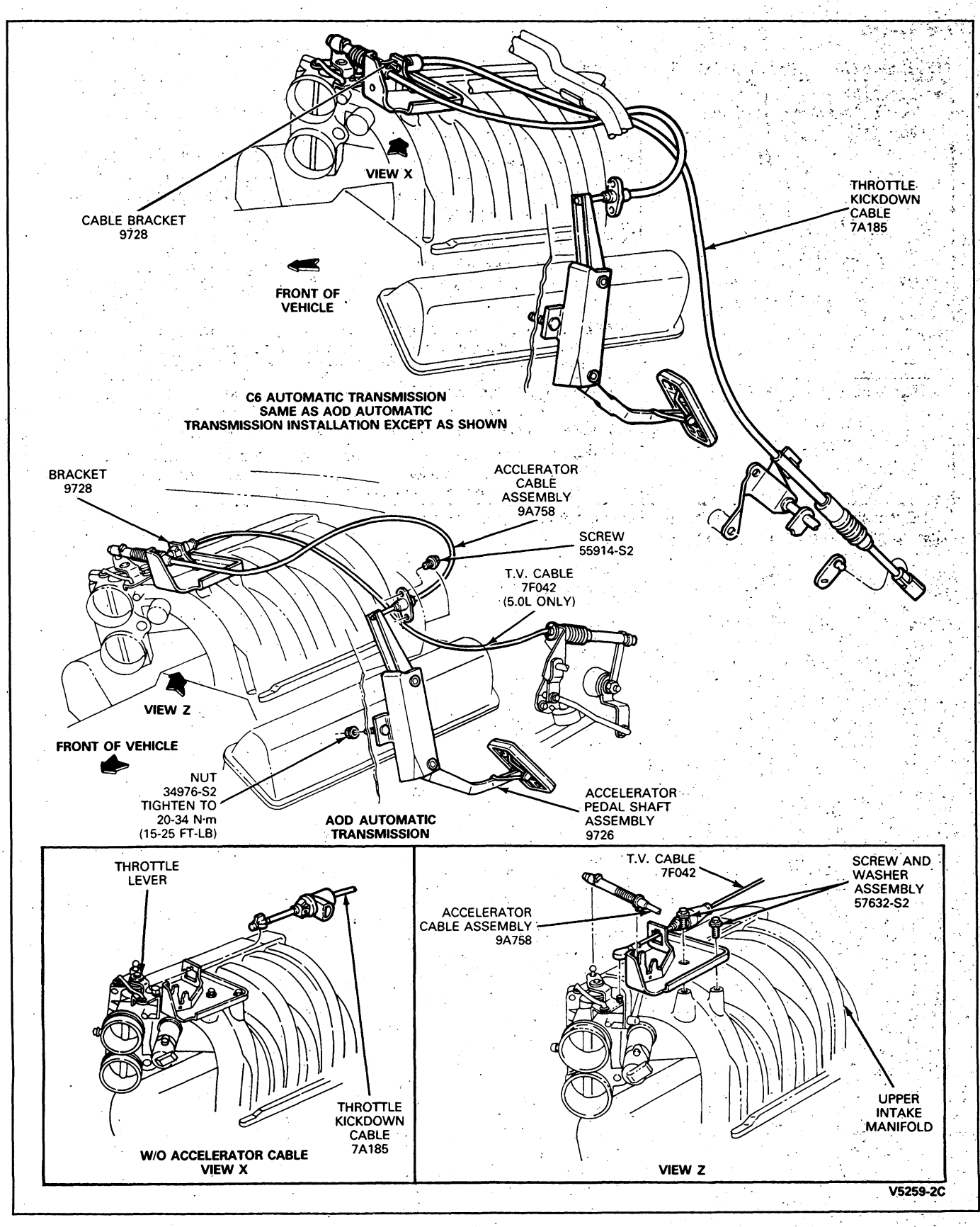


FIG. 5 Throttle Linkage—E-150—E-250 with 5.0L (302 CID) EFI or 5.8L (351 CID) EFI Engines

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DIAGNOSIS

ACCELERATOR PEDAL TO THROTTLE BODY

• Accelerator pedal is hard to push down or has a rough/raspy or sticky feel.	• Disconnect cable end from ball stud at throttle body ensuring the disconnected end of the cable or its spring does not come into contact with any of the surrounding parts. • Operate the pedal by hand, observing and feeling that the full pedal range of travel is not restricted by the dash panel insulator or carpet/mat/padding. If full pedal travel to WOT is restricted, adjust insulator and/or trim items as required. • Operate the pedal by foot. • If cable operation is smooth, refer to the throttle body diagnosis procedures in the appropriate section in the Engine/Emissions Diagnosis Manual, Vol. H*. • If the condition reoccurs (being sure disconnected end of cable has not come into contact with anything), check the foot pedal assembly for free operation. If the pedal operation is free, replace the cable.
• High engine idle speed.	• If the cable ball socket extends beyond the throttle lever ball stud, refer to the throttle body diagnosis procedures in the appropriate section in the Engine/Emissions Diagnosis Manual, Vol. H*. • If the socket does not extend beyond the stud, check the foot pedal assembly for free operation (free from carpet, mats, wiring, etc. contact). If the pedal operation is free, replace the cable.

NOTE: Accelerator cable should not be lubricated and it is not serviceable.
*Can be purchased as a separate item.

CV4247-2E

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GROUP

FUEL SYSTEM— DIESEL ENGINES 25

(9000 D)

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FUEL FILTERS—DIESEL ENGINES	25-51-1
FUEL SUPPLY PUMP— DIESEL ENGINE	25-02-1
FUEL TANKS AND LINES—DIESEL ENGINES	25-50-1
THROTTLE LINKAGE—DIESEL	25-60-1

SECTION 25-02 Fuel Supply Pump—Diesel Engine

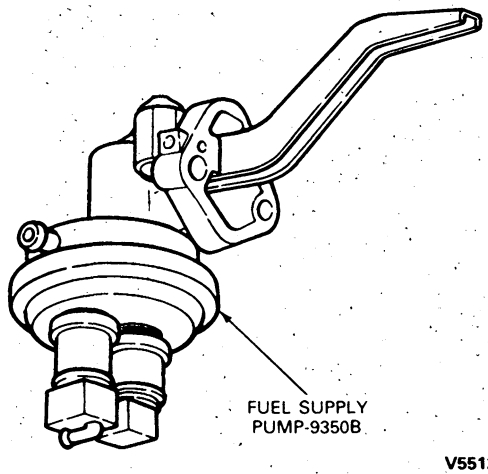
SUBJECT	PAGE
DESCRIPTION	25-02-1
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TESTING	
Capacity (Volume) Test	25-02-4
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VEHICLE APPLICATION	25-02-1

VEHICLE APPLICATION

F-Series, Econoline—and Super Duty Series Vehicles Equipped With Diesel Engines.

DESCRIPTION

The fuel supply pump is bolted to the right-front side of the cylinder block on the 7.3L—V-8 diesel engine.



V5512-1A

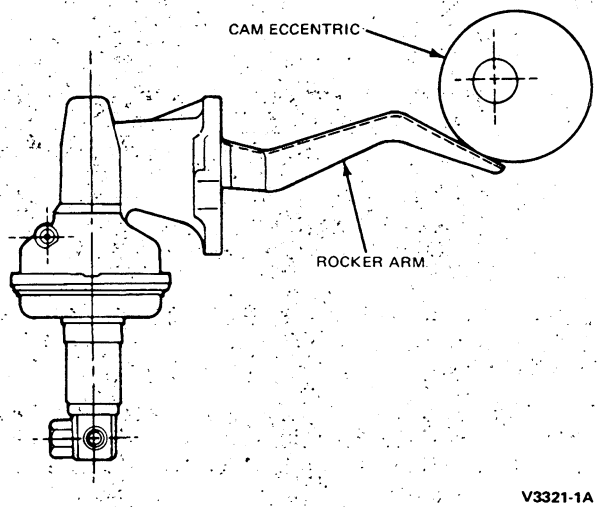
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DESCRIPTION (Continued)

The pump is mechanically operated by an eccentric cam located on the camshaft. The pump rocker arm riding against the eccentric provides the diaphragm up-and-down pumping motion.

The fuel supply pump cannot be disassembled for repairs and must be replaced if testing indicates it is not within performance specifications.

WARNING: NO SMOKING OR OPEN FLAME OF ANY TYPE SHOULD BE PRESENT WHEN WORKING NEAR FUEL OR FUEL VAPOR.



DIAGNOSIS

If the fuel pump is damaged or worn, it normally will not deliver any fuel or will not deliver adequate fuel to sustain high engine speeds or loads.

When an engine has a lean (fuel starving) condition the fuel supply pump is often suspected to be the problem. Similar symptoms will be present if the fuel filter is plugged or restricted, if the fuel/water separator is contaminated, if fuel lines and hoses are leaking, kinked or restricted.

NOTE: Refer to Volume H of Shop Manual for further diagnosis.

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DIAGNOSIS (Continued)

If the fuel pump is suspected of being noisy, check for:

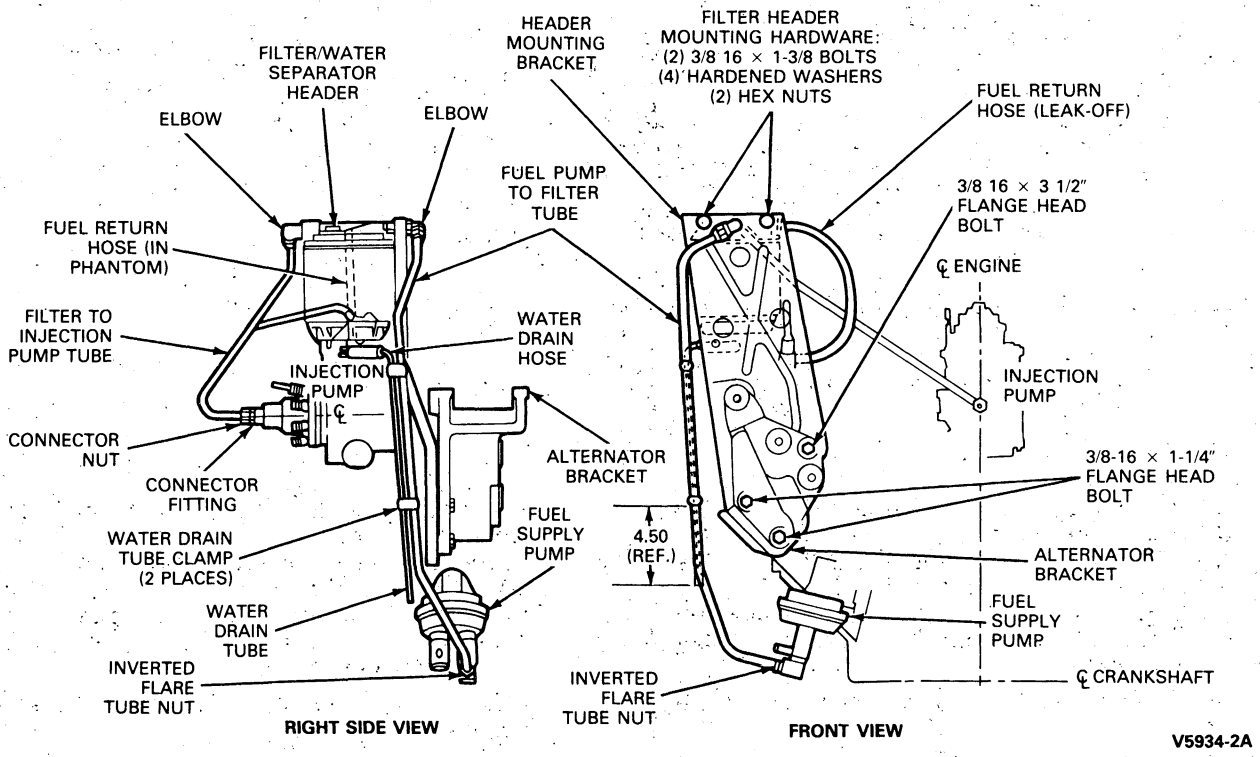
1. Loose fuel pump mounting bolts. Tighten to 26-37 N·m (19-27 ft-lb), if loose. Replace gasket if damaged or worn.
2. Check for loose or missing fuel line attaching clips. This condition will result in the noise being more audible when sitting inside the vehicle than standing outside of it. Tighten clips on fuel lines if necessary.

Before removing a suspect fuel pump:

1. Ensure there is adequate fuel in the tank.
2. Ensure the fuel filter is not plugged. If it has not been changed recently, install a new filter.
3. Inspect all rubber hoses from the fuel pump to fuel tank for kinks or cracks. With engine idling, inspect all fuel lines and rubber hoses and connections from fuel pump to fuel tank for fuel leaks. Tighten loose connections and replace kinked, cracked or leaking fuel lines or hoses as required.

NOTE: Leaking lines or hoses and kinked hoses will severely affect fuel pump performance.

4. Inspect the fuel pump outlet connection for fuel leaks. Tighten to 20-24 N·m (15-18 ft-lb), if required.
5. Inspect the fuel pump diaphragm crimp (the area where the stamped steel section is attached to the casting) and the breather hole(s) in the casting for evidence of fuel or oil leakage. Replace pump if leaking.



To determine if the fuel pump is performing properly, test the fuel pump for capacity (volume) and pressure, with the fuel pump installed on the engine. If the engine is excessively hot, let it cool for 20-30 minutes.

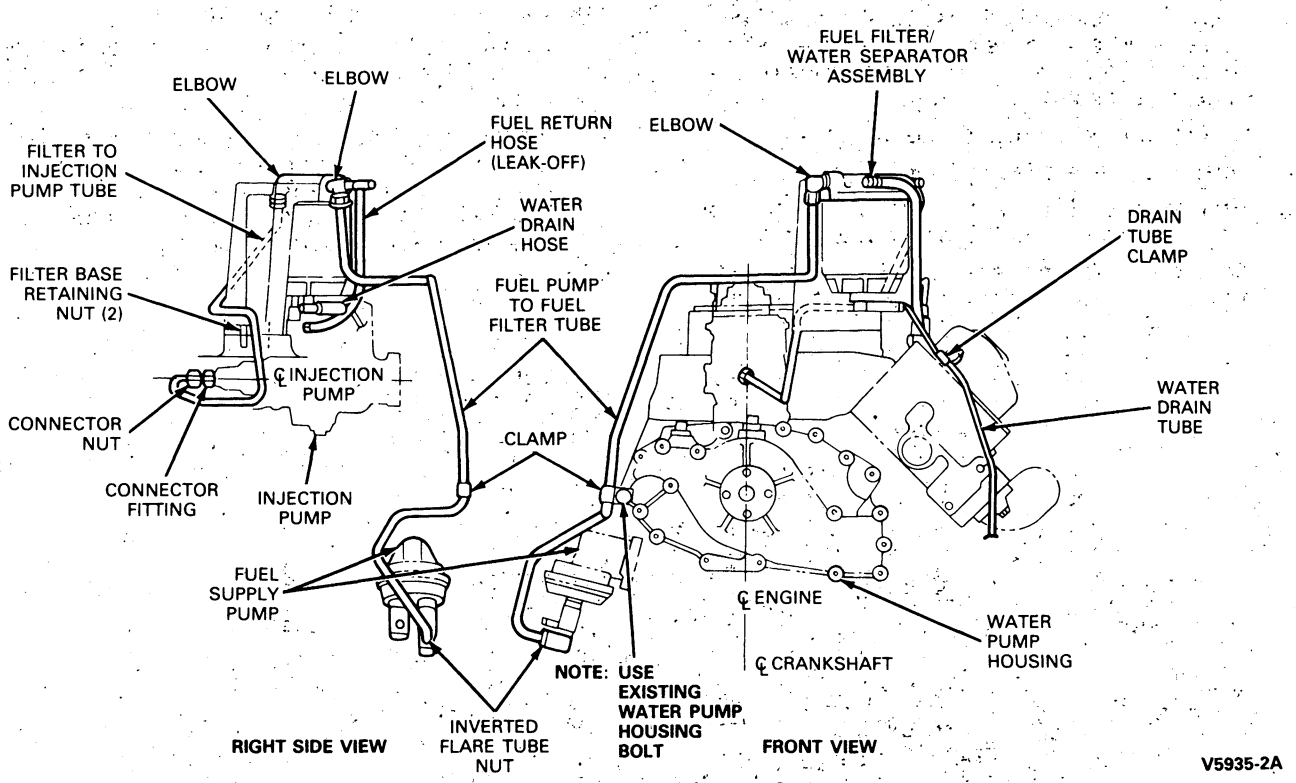
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TESTING

Capacity (Volume) Test

1. Slowly (fuel line is pressurized) disconnect the fuel line at the fuel filter.

WARNING: USE CARE TO PREVENT COMBUSTION OF SPILLED FUEL.



2. Place a suitable non-breakable container (1/2 liter or 1 pint minimum) Rotunda Safety Can 018-00003, or equivalent at the end of the disconnected fuel line (a piece of hose may be needed on the fuel line end). Crank engine ten seconds. The fuel pump should deliver 1/3 pint of fuel, or more.
3. If fuel flow is to specification, perform pressure test.
4. If fuel flow is low, repeat test using a remote non-breakable container of diesel fuel. Remove fuel hose from fuel pump inlet supply line. Connect a length of fuel hose from the fuel supply line to the non-breakable container and repeat Step 3. If fuel flow is to specification, the problem is either a plugged fuel/water separator or, a kinked or leaking fuel hose. Service as necessary.
5. If fuel flow is below specification, replace fuel pump.

Pressure Tests

1. Connect Rotunda Vacuum and Pressure Tester 059-00008 or equivalent (0-103 kPa or 0-15 psi) to the injection pump end of the fuel line. (No "T" is required.)
2. Crank the engine for 10 seconds and read the pressure. Refer to the fuel system specification at the end of this Section for the fuel pressure specification. If pump pressure is too low or too high install a new fuel pump.
3. Connect fuel line.

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REMOVAL AND INSTALLATION

Removal

1. Loosen the threaded connection(s) with the proper size wrench (flare nut wrench preferred) and tighten snugly. Do not remove lines at this time. If rubber hose outlet connection is used go to Step 2.
2. Loosen mounting bolts approximately two turns. Apply force with hand to loosen fuel pump if gasket is stuck. Rotate the engine, by nudging the starter, until the fuel pump cam lobe is near its low position. The tension on the fuel pump will be greatly reduced at the low cam position.

NOTE: Outlet line is pressurized.

3. Disconnect the fuel pump inlet, outlet and fuel vapor return line, if so equipped.

WARNING: USE CARE TO PREVENT COMBUSTION OF SPILLED FUEL.

4. Remove the fuel pump attaching bolts and remove the pump and gasket. Discard the old gasket.

Installation

1. Remove all fuel pump gasket material from the engine and the fuel pump if installing the original pump.
2. Install the attaching bolts into the fuel pump and install a new gasket on the bolts. Position the fuel pump to the mounting pad. Turn the attaching bolts alternately and evenly and tighten them to 26-37 N·m (19-27 ft-lb).
3. Install fuel outlet line. If it is a threaded connection, start fitting by hand to avoid crossthreading. Tighten to 20-24 N·m (15-18 ft-lb).
4. Install inlet line. Install hose clamp(s).

NOTE: If rubber hoses are cracked, hardened or frayed, replace them with new "gasoline" rubber hose.

5. Start engine and observe all connections for fuel leaks for two minutes.
6. Stop engine and check all fuel pump fuel line connections for fuel leaks by running a finger under the connections. Check for oil leaks at the fuel pump mounting gasket.

SPECIFICATIONS

Engine Liter (CID)	Static Pressure kPa (PSI)①	Mounting Bolts N·m (Ft-Lb)	Fuel Lines to Pump N·m (Ft-Lb)
7.3L (445)	41-55 (6-8)	26-37 (19-27)	20-24 (15-18)

① On engine with temperatures normalized and at normal curb idle speed, transmission neutral. CV5514-2B

ROTUNDA EQUIPMENT

Model	Description
059-00008	Vacuum and Pressure Tester
018-00003	Safety Can

CV2454-1E

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SECTION 25-40 Air Cleaner—Diesel

SUBJECT	PAGE
DESCRIPTION	25-40-1
REMOVAL AND INSTALLATION	
Filter Element	25-40-1
VEHICLE APPLICATION	25-40-1

VEHICLE APPLICATION

7.3L Diesel Engine.

DESCRIPTION

A dry-type air cleaner is standard equipment on all Ford trucks equipped with diesel engines. Air is filtered through a pleated, chemically treated paper element to remove contaminants before entering the engine induction system.

Air cleaner installations are shown in Figs. 1, 2 and 3.

REMOVAL AND INSTALLATION

Filter Element

Removal

1. Loosen wing bolt. Then, remove air cleaner assembly as a unit before disassembly.

Before installing a new element in the air cleaner, check the following items:

a. Gasket surfaces should be clean and undamaged.

b. Inlet tube should be clean and undamaged.

c. Element should be dry and free of holes, ruptures, damaged gaskets or dents in end covers and liners.

d. Element retaining nut or bolt should have the gasket washer attached and it should be in good condition.

e. Inspect water drain hose (F-Series only) for possible restrictions caused by contaminants. Replace hose (9F765) if cracked or damaged.

Installation

After the air cleaner, element, dust cup and other parts are found to be in good condition, reassemble the parts.

1. Install the element. Ensure the rubber face of the washer seals against the element.

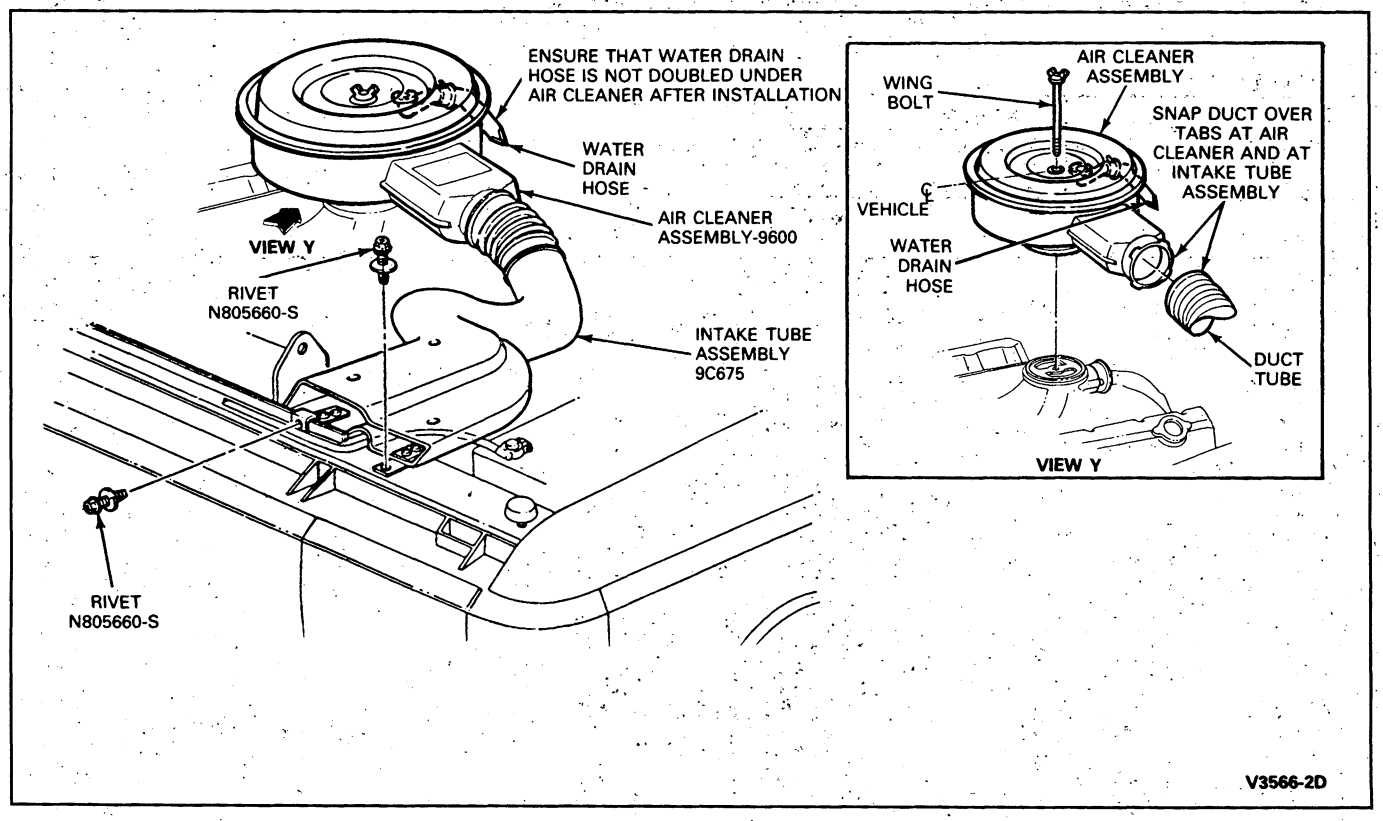


Fig. 1 Typical Installation for F-150—F-350—7.3L Diesel Engine

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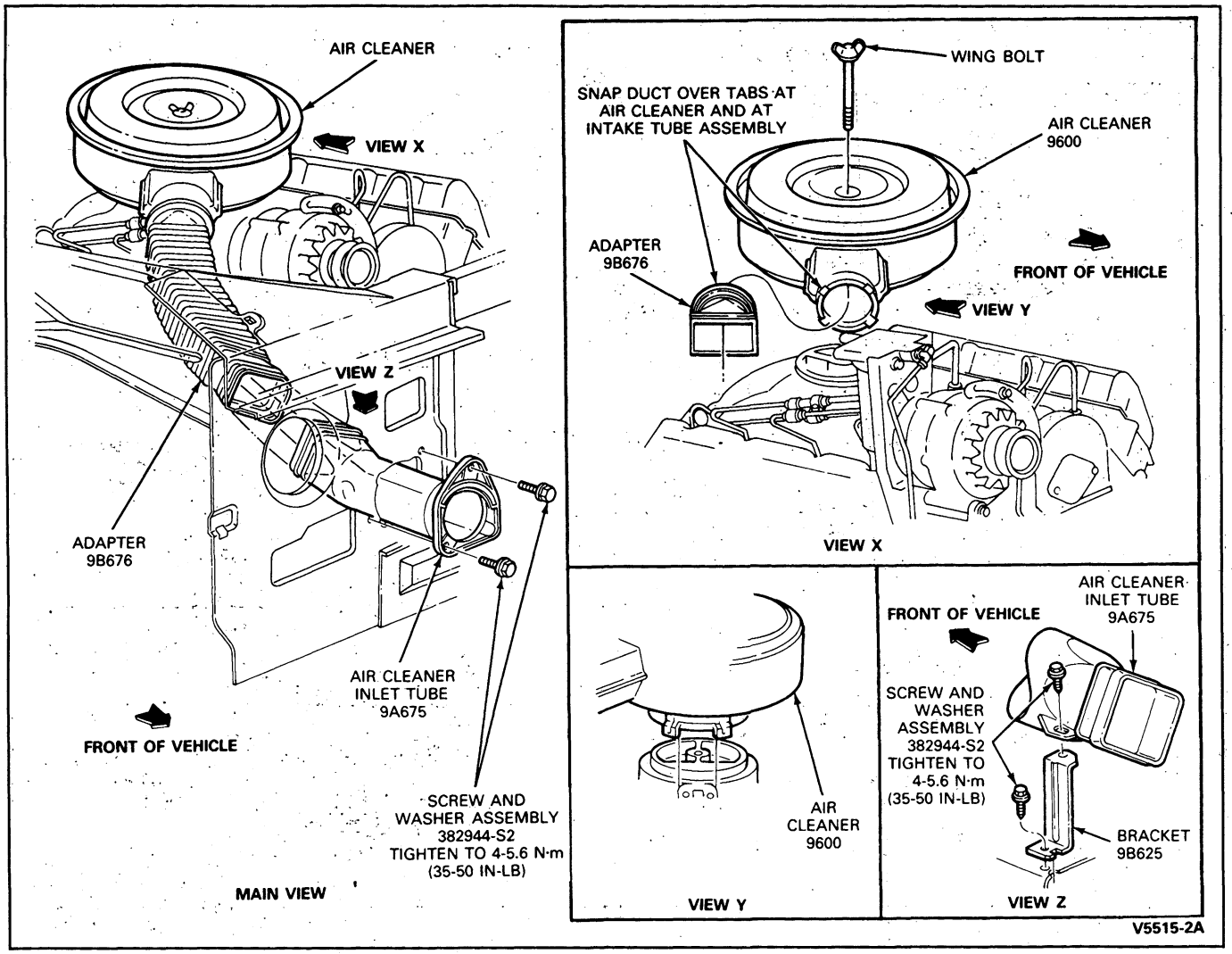


Fig. 2 Typical Installation for E-150—E-350—7.3L Diesel Engine

CAUTION: On F-Series, a special water resistant element is required. Ensure to use only a specific Ford replacement. Use of other elements could result in serious engine damage.

2. Install the cover. Ensure gasket, if supplied, is in place. Replace a worn or damaged gasket.
3. Install air cleaner assembly and tighten wing bolt securely.
4. On F-Series only, ensure that the rubber water drain hose is not doubled under, kinked or bent and is positioned freely.

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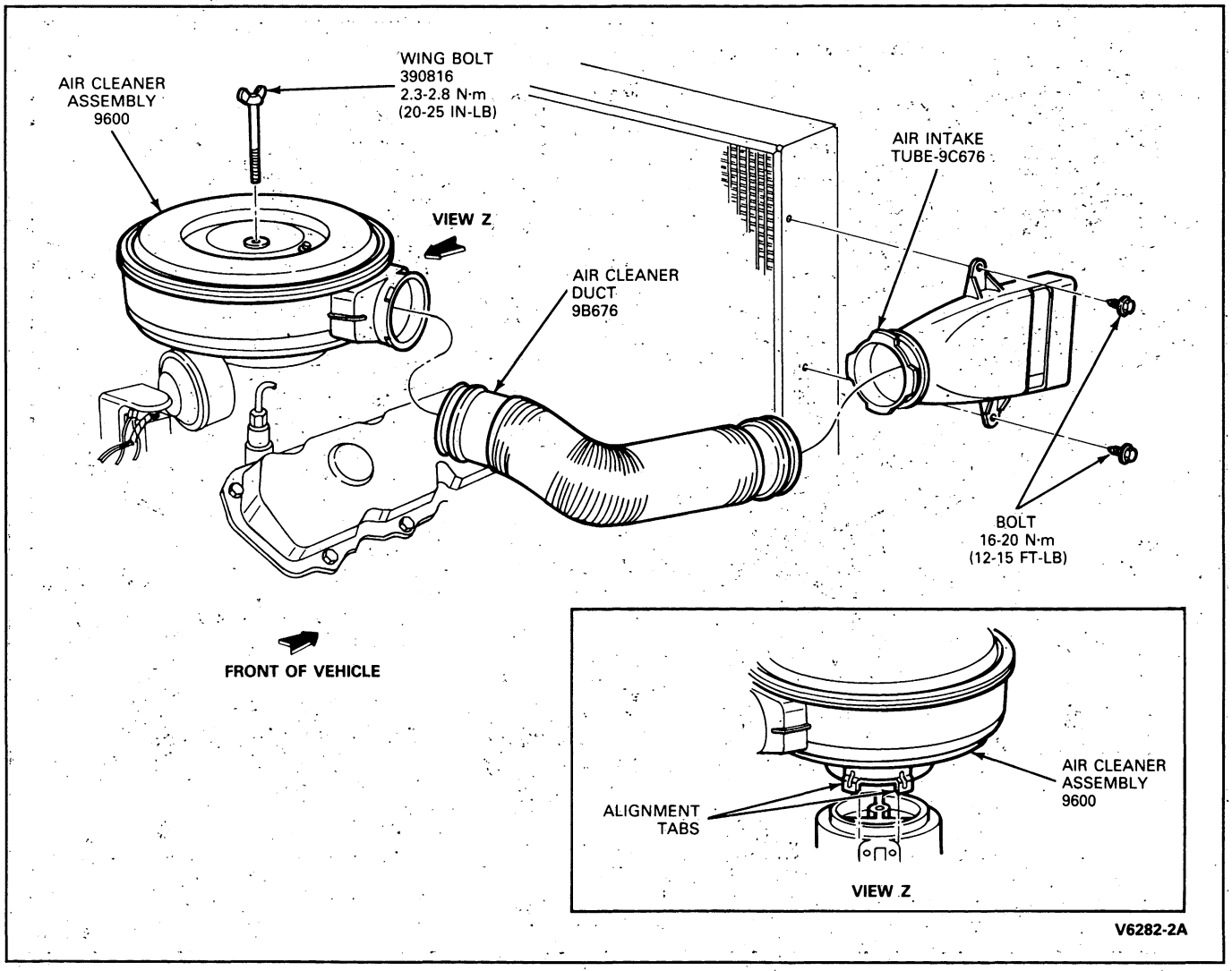


FIG. 3 Installation—F-Super Duty Commercial Stripped Chassis Vehicles—7.3L Diesel Engine

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SECTION 25-50 Fuel Tanks and Lines—Diesel Engines

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Fuel Tank Filling	25-50-1
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SPECIAL SERVICE TOOLS	25-50-30
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VEHICLE APPLICATION	25-50-1

VEHICLE APPLICATION

All Models With 7.3L Diesel Engine

DESCRIPTION

Typical fuel tank and line installations are shown in Figs. 6 through 22. Refer to these illustrations and remove damaged or worn parts as necessary.

Push Connect Fittings

Push connect fittings are used to make most fuel line connections in diesel fuel systems. These fittings must be serviced as outlined. Service is not possible if the fitting is damaged, except to replace a damaged retaining clip.

Fuel Tank Filling

Expansion of fuel due to temperature increases, or overfilling ("topping off") could cause fuel overflow at the filler cap when the vehicle is standing or the cap is removed. To minimize this condition, it is recommended that the amount of fuel put in the tank when filling be limited to the automatic pump shutoff. If vehicle has two tanks, use fuel from both tanks after fill-up to reduce fuel levels.

Fuel Tank Draining

Use appropriate adapter to connect Rotunda Suction Pump 034-00006 or equivalent suction pump to the fuel hose (at the fuel sedimenter-to-fuel tube connection) and drain the fuel tank.

Fuel Selector Valve (Vehicles with Dual Tanks Only)

Refer to Figs. 1, 2 and 3.

The 6-port diesel fuel valve is powered by a small electric motor which opens and closes the valve ports. The supply and return ports for either tank open and close simultaneously. The valve is shifted to the front

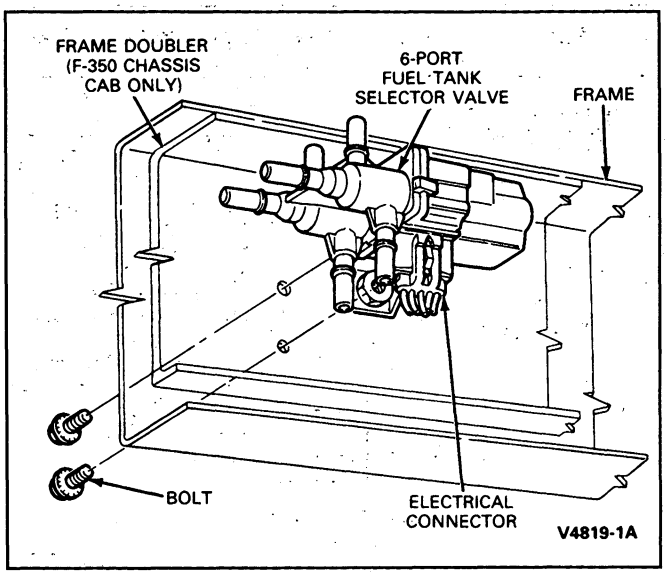


FIG. 1 Fuel Tank Selector Valve—Typical

mode (that is the front supply and return ports open to the engine supply and engine return port respectively) by applying a positive 12 volts to terminal number 2 and ground to terminal number 1. When the valve reaches the front mode position, an internal switch opens the circuit and stops the motor. Returning the valve to the rear mode is accomplished by reversing power: positive 12 volts to terminal number 1 and ground to terminal number 2. Terminals 3 and 5 connect to the front and rear fuel tank senders respectively, and terminal 4 feeds the fuel gauge. In the front tank mode an internal switch connects terminal 3 to terminal 4, thus supplying the front tank sender signal to the fuel gauge. Terminals 4 and 5 are connected in the rear tank mode. Therefore, a change in the fuel gauge reading (assuming at least 1/4 tank fuel level difference), means that the valve has shifted.

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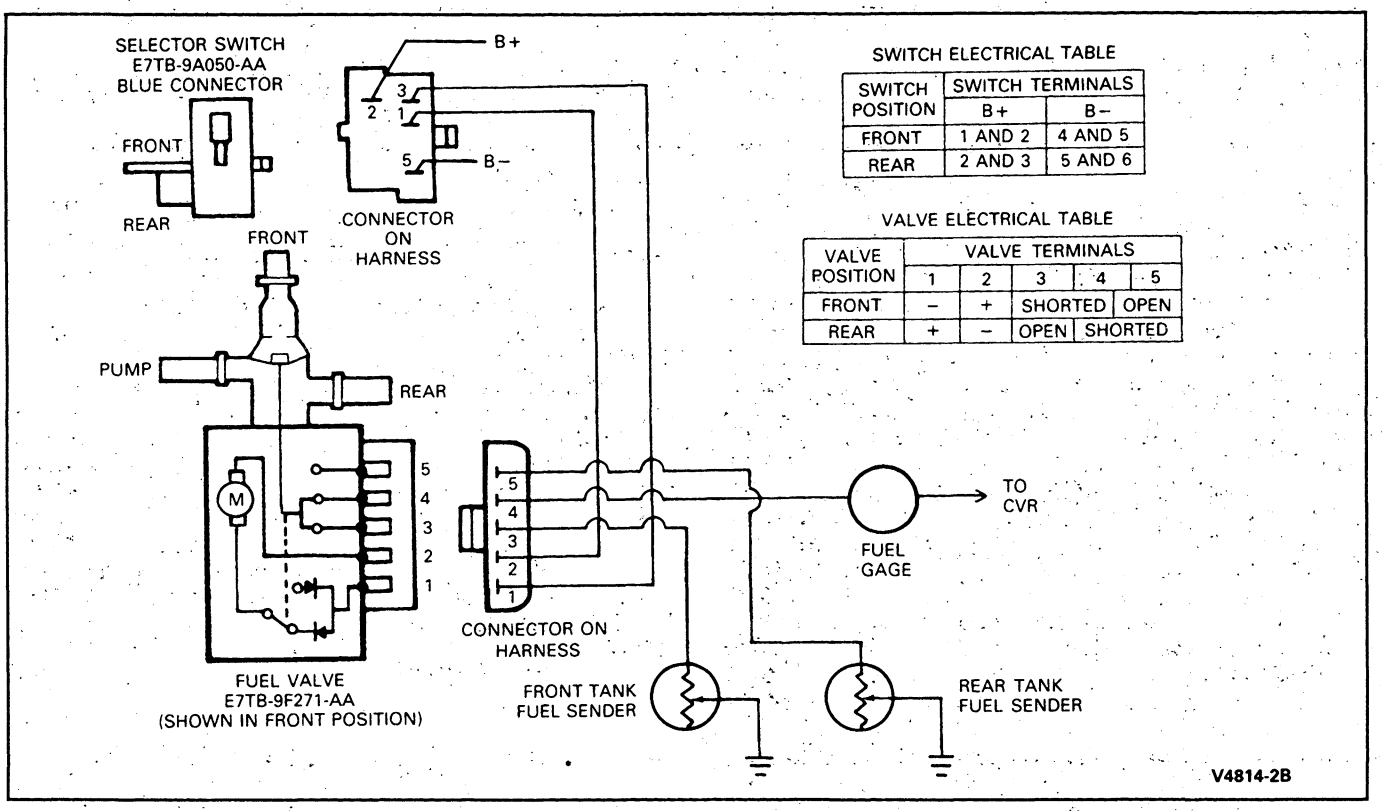


FIG. 2 Fuel Tank Selector Valve Wiring Diagram—F-250—F-350

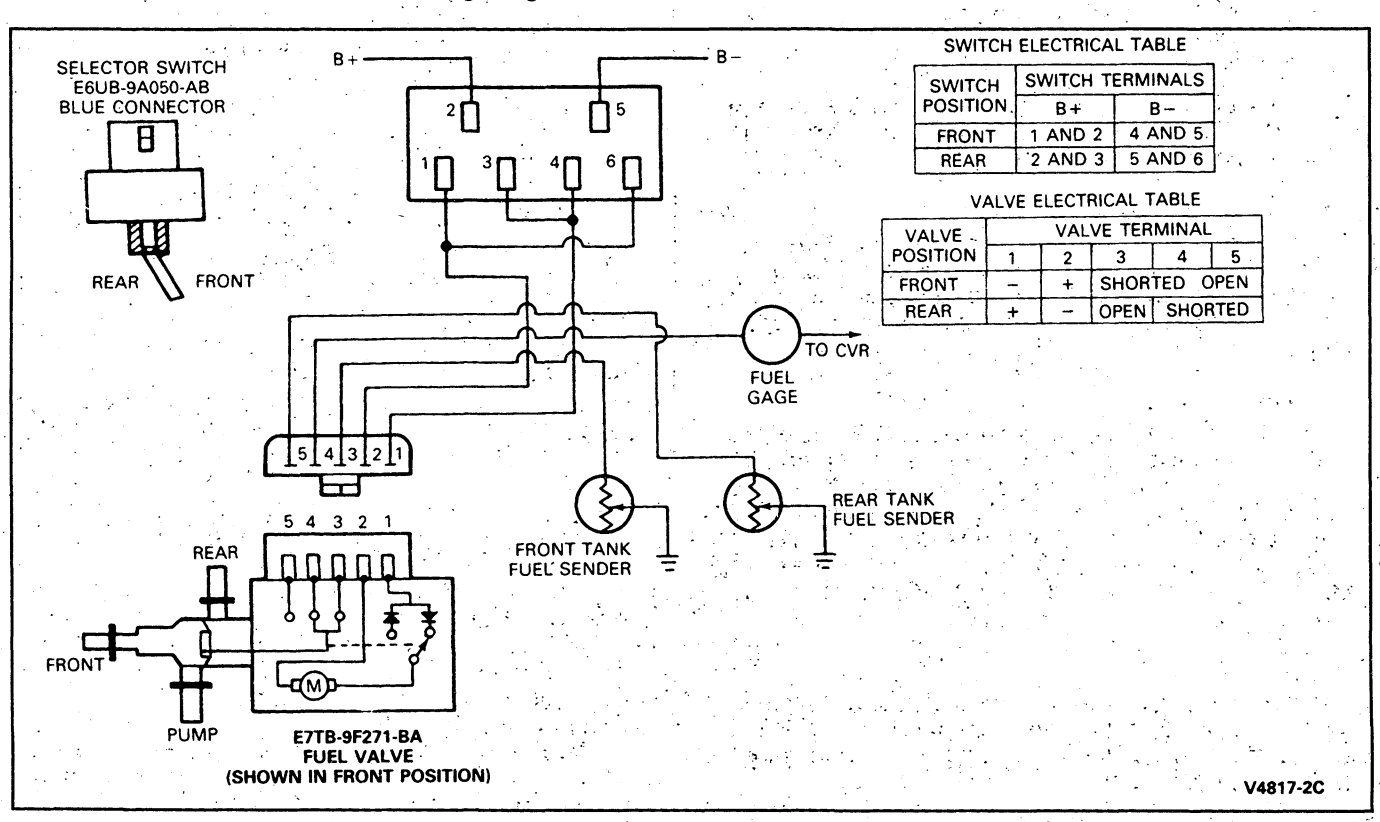


FIG. 3 Fuel Tank Selector Valve Wiring Diagram—E-250—E-350

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Power is supplied to the fuel tank selector switch from the fuse panel when the ignition switch is in the ON position. This power goes through the fuel tank selector switch directly to the motorized fuel tank selector valve.

With the fuel tank selector switch in the front tank position, power is supplied from the selector switch to terminal number 2 of the fuel selector valve (Figs. 2 and 3). The ground path is completed through terminal number 1 of the fuel tank selector valve and is grounded through the selector switch. This causes the fuel selector valve to rotate internally, opening the ports to the front tank position which allows fuel to flow through the fuel line to the engine.

With the fuel tank selector switch in the rear tank position, power is supplied from the selector switch to terminal number 1 of the fuel tank selector valve. The ground path is completed through terminal number 2 of the fuel tank selector valve and is grounded through the selector switch. This current path causes the motorized valve to rotate internally, opening the ports to the rear tank position which allows fuel to flow through the fuel line to the engine.

NOTE: When diagnosing the selector valve for failure to switch tanks and voltage is on terminals number 1 and number 2 of the valve, ensure the ground wire is attached below the instrument panel.

Fuel/Water Separator

Water should be drained from the engine mounted fuel/water separator whenever the warning lamp comes on or every 8046 km (5000 miles). More frequent drain intervals may be required depending on fuel quality and vehicle usage.

The instrument panel warning lamp (WATER IN FUEL) will glow when approximately 0.1 liter (0.1 quart) of water has accumulated in the sedimenter. When the warning lamp glows, shut off the engine as soon as safely possible.

Drain Procedure

Refer to Section 22-08, 7.3L V-8 Diesel Engine.

DIAGNOSIS

Refer to the following diagnosis charts for fuel valve system troubleshooting.

For diagnosis of fuel indicating system problems with fuel selector valve, refer to Fuel Indicating Systems, Section 33-20. For the following diagnostic procedure both tanks must contain some usable fuel.

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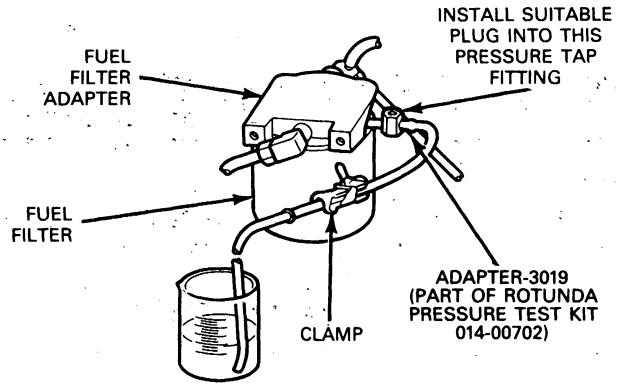
FUEL SELECTOR VALVE DOES NOT CHANGE TANKS — 7.3L DIESEL WITH DUAL TANKS

TEST STEP		RESULT ▶	ACTION TO TAKE
A1	CHECK FOR VOLTAGE		
	• Disconnect electrical connector from tank selector valve. • Turn ignition to RUN position. • Move selector switch to Front position and check for voltage between connector terminals No. 2 and No. 1.	Voltage present ▶ No voltage present ▶	GO to **A2**. GO to **A5**.
A2	CHECK VOLTAGE		
	• Check voltage between terminal No. 2 and ground.	Voltage present ▶ No voltage present ▶	GO to **A3**. GO to **A5**.
A3	CHECK FUEL VALVE MOTOR		
	• Jumper motor terminal No. 2 to battery positive and motor terminal No. 1 to frame ground. • Motor should run. • Reverse jumper leads to motor. • Motor should run in opposite direction.	Motor runs in both directions ▶ Motor does not run in one or both directions ▶	GO to **A6**. REPLACE motor.
A4	CHECK GROUND CIRCUIT		
	• Check for open ground circuit from motor, through switch to ground.	(OK) ▶ (OK) ▶	GO to **A6**. REPAIR ground circuit.
A5	CHECK FUSE		
	• Check for voltage across fuse No. 15 (10 Amp) in fuse panel.	(OK) ▶ (OK) ▶	GO to **A6**. REPAIR short(s) in selector valve circuits as necessary. REPLACE fuse. REPEAT Test Step **A1**.
A6	CHECK SELECTOR SWITCH CONTINUITY		
	• Remove fuel tank selector switch mounting screws and disconnect switch from harness connector. • With selector switch in Front (F) position, check for continuity between terminals No. 1 and No. 2 and between terminals No. 4 and No. 5. • Move selector switch in REAR (R) position, and check continuity between terminals No. 2 and No. 3 and between terminals No. 5 and No. 6.	(OK) ▶ (OK) ▶	GO to **A7**. REPLACE fuel selector switch.

CV4262-2D

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FUEL SELECTOR VALVE DOES NOT CHANGE TANKS — 7.3L DIESEL WITH DUAL TANKS (Continued)

TEST STEP	RESULT	ACTION TO TAKE
A7 CHECK CONTINUITY OF CIRCUITS 974 and 674 • Check continuity of circuits 786 (red) and 789 (brown/white) between selector switch and selector valve.	OK ▶ Not OK ▶	GO to **A8**. REPAIR open circuit(s) as necessary.
A8 CHECK FOR FUEL FLOW FROM FRONT TANK • Turn ignition to RUN position. • Move selector switch to FRONT position and turn ignition OFF. • Disconnect the fuel supply line from rear tank to selector valve. • Remove vacuum purge valve from fuel filter adapter. • Install adapter 3019 from Rotunda Pressure Test Kit 014-00702 or equivalent. • Start engine and let idle with no load. • Open clamp on sample hose, allowing fuel to flow into a suitable container. • Check for solid, continuous flow of fuel.  	OK ▶ Not OK ▶	CONNECT rear supply line. GO to **A11**. GO to **A9**.
A9 BY-PASS FUEL SELECTOR VALVE • Disconnect the supply line to the engine at the selector valve. • Disconnect the supply line from the front tank at the selector valve. • Connect the two lines together using a suitable length of fuel hose equipped with two male connectors and repeat Test Step A8.	OK ▶ Not OK ▶	REPLACE fuel selector valve. GO to **A10**.
A10 CHECK SYSTEM FOR RESTRICTIONS • Check front fuel tank sender, sedimentor, fuel filter and fuel lines for kinks or restrictions.	OK ▶ Not OK ▶	CHECK fuel tank for sufficient amount of fuel. REPEAT Test Step **A8**. CLEAN, REPAIR or REPLACE components as necessary. REPEAT Test Step **A8**.

CV4263-2E

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FUEL SELECTOR VALVE DOES NOT CHANGE TANKS — 7.3L DIESEL WITH DUAL TANKS (Continued)

TEST STEP		RESULT	ACTION TO TAKE
A11	CHECK FUEL FLOW FROM REAR TANK		
• Turn ignition to RUN position. • Move selector switch to REAR position and turn ignition OFF. • Disconnect the fuel supply line from front tank to selector valve. • Remove vacuum purge valve from fuel filter adapter. • Install adapter 3019 from Rotunda Pressure Test Kit 014-00702, or equivalent, see step A8. • Start engine and let idle with no load. • Open clamp on sample hose, allowing fuel to flow into a suitable container. • Check for solid, continuous flow of fuel.		OK ▶ OK ▶	Fuel supply system OK. CONNECT fuel line to fuel injection pump. CONNECT the front tank supply line. GO to Test Step **B1**. GO to **A12**.

CV5048-2B

FUEL SELECTOR VALVE DOES NOT CHANGE TANKS — 7.3L DIESEL WITH DUAL TANKS (Continued)

TEST STEP		RESULT	ACTION TO TAKE
A12	BY-PASS FUEL SELECTOR VALVE		
• Disconnect the supply line to the engine at the selector valve. • Disconnect the supply line from the rear tank at the selector valve. • Connect the two lines together using a suitable length of fuel hose equipped with two male connectors and repeat Test Step **A8**.		OK ▶ OK ▶	REPLACE fuel selector valve. GO to **A13**.
A13	CHECK SYSTEM FOR RESTRICTIONS		
• Check rear fuel tank sender and fuel lines to selector valve for kinks and restrictions.		OK ▶ OK ▶	CHECK fuel tank for sufficient amount of fuel. REPEAT Test Step **A11**. CLEAN, REPAIR or REPLACE components as necessary. REPEAT Test Step **A11**.

CV4264-2B

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ENGINE RUNS ROUGH OR FLOODS OUT — ONE TANK POSITION ONLY — 7.3L DIESEL WITH DUAL TANKS

TEST STEP	RESULT ▶	ACTION TO TAKE
B1 CHECK FUEL RETURN TO SELECTOR VALVE • Disconnect fuel return line from engine at selector valve and insert line into suitable container. • Turn ignition to RUN position and move tank selector switch to problem tank. • Start engine and check for a solid, continuous flow of fuel.	(OK) ▶	TURN engine OFF. CONNECT fuel return line to selector valve. GO to **B2**.
	(OK) ▶	CHECK return line for kinks or restrictions. REPAIR or REPLACE as necessary. REPEAT Test Step **B1**.
B2 CHECK FUEL RETURN TO TANK • Disconnect fuel return line from the problem tank from selector valve. • Attach a length of 7.9mm (5/16 inch) diameter hose to selector valve return port and insert line into suitable container. • Start engine and check for a solid, continuous flow of fuel.	(OK) ▶	CHECK fuel sender and fuel line to tank for kinks or restrictions. REPAIR or REPLACE as necessary. RUN engine and CHECK for smooth running.
	(OK) ▶	REPLACE fuel valve.

CV4265-2C

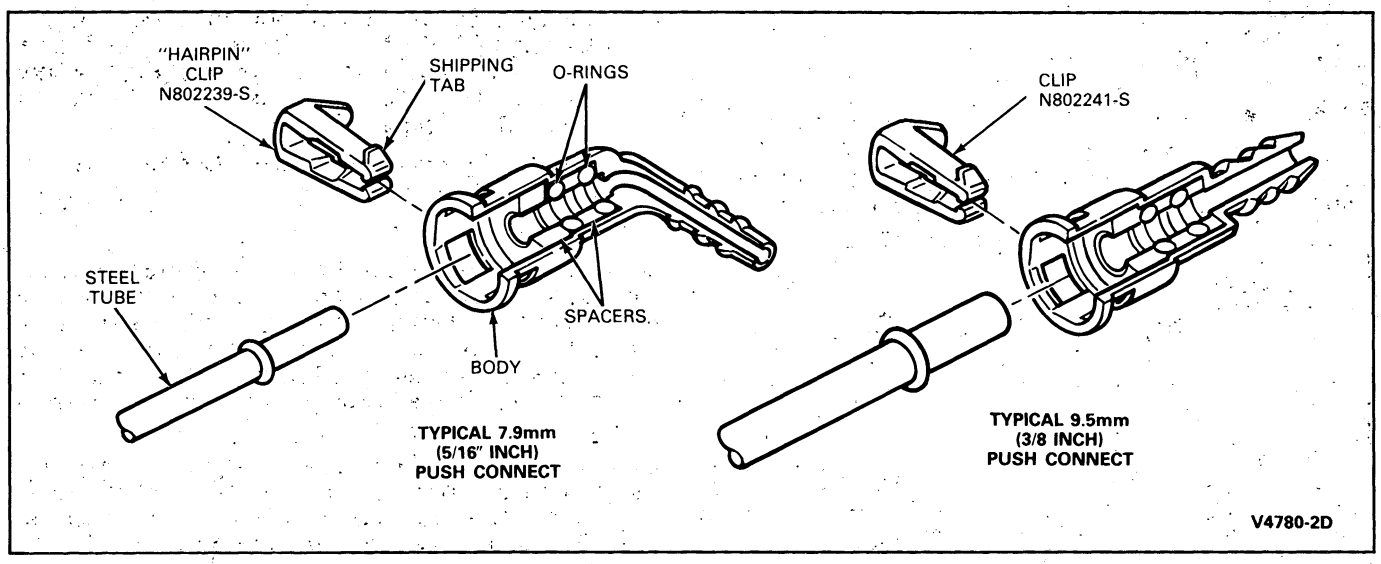


FIG. 4 Typical Push Connect Fittings

REMOVAL AND INSTALLATION

NOTE: Torque specifications are included on applicable figures.

Fuel Lines and Hoses

Push Connect Fittings

Push connect fittings for 7.3L diesel systems have two sizes for 9.5mm (3/8-inch) and 7.9mm (5/16-inch) tubing.

Disconnect all push connect fittings from components (sender, 6-way valve) prior to component removal. The push connect fittings to connect flexible fuel lines to the fuel tank sender often cannot be disconnected until the tank is partially lowered, just before removing the fuel tank completely (Fig. 4).

7.9mm (5/16-Inch) or 9.5mm (3/8-Inch) Fittings

Removal

1. Inspect the visible internal portion of fitting for dirt accumulation. If more than a light coating of dust is present, clean the fitting before disassembly.
2. Some adhesion between the seals in the fitting and tubing will occur with time. To separate, twist the fitting on the tube, then push and pull the fitting until it moves freely on the tube.
3. Remove "hairpin" type clip from fitting by first bending the shipping tab downward so that it will clear the body (Fig. 4). Next **(using hands only)**, spread the two clip legs about 3.0mm (1/8 inch) each to disengage the body and push the legs into

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the fitting. Complete removal is accomplished by **lightly** pulling from the triangular end of the clip and working it clear of the tube and fitting.

CAUTION: Do not use any tools.

4. Grasp the fitting and hose assembly and pull in an axial direction to remove the fitting from the tube.
5. When fitting is removed from the tube end, inspect the fitting and tube for any internal parts that may have been dislodged from the fitting. Any loose internal parts should be immediately installed, using the mating tube to insert the parts.

Installation

1. It is recommended that the original retention clip **not** be reused in the fitting. To install the new clip, insert clip into any two adjacent openings with the triangular portion pointing away from the fitting opening. Install clip to fully engage the body (legs of "hairpin" clip locked on outside of body). Piloting with an index finger is necessary.
2. Before installing the fitting on the tube, wipe tube end with a clean cloth. Inspect the inside of the fitting to ensure it is free of dirt and/or obstructions.
3. To install the fitting onto the tube, align the fitting and tube axially and push the fitting onto the tube end (Fig. 5). When the fitting is engaged, a definite click will be heard. Pull on fitting to ensure it is fully engaged.

Fuel Lines—Steel

Engine Compartment

Fuel supply tubes and the various fuel lines need not be serviced as assemblies. They may be cut, squared and formed out of rolls of fuel system service tubing and hose material available at dealerships, or a service part may be purchased.

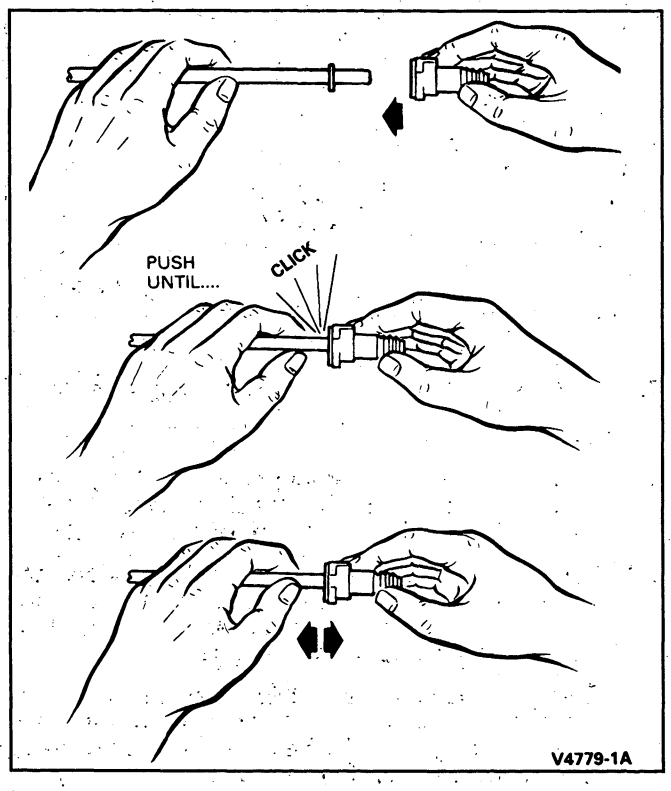


FIG. 5 Connecting "Push Connect" Fittings

A damaged section of tubing longer than 305mm (12 inches) can be cut out of the existing line and replaced by a comparable service tubing section, spliced into the line by means of connecting hoses and retaining clamps. A damaged section of tubing shorter than 305mm (12 inches) can be cut out of the line and replaced by a length of service hose and two retaining clamps.

All replacement hoses must be cut to a length that will ensure proper clamp retention.

Removal

1. Disconnect the damaged line at both ends. Remove the line from the holding clips along the frame. Remove all damaged hose and tube sections.

Installation

1. Cut a new section of tubing to approximately the same length as the section to be replaced. Allow extra length for flaring the ends of the tubing where required. Square the ends of the cut tubing with a file.
2. Ream the inside edges of the cut tubing with the reamer blade on the tube cutter. Be sure metal chips are removed from inside the tube(s). Double flare the ends of the cut tubing, as required.
3. Bend the tube section to conform to the contour of the original tube. Cut an ample length of hose to form a coupling between the ends of the fuel lines. Connect the hose couplings to the tubing and install the retaining clamps.
4. Position the lines in the clips. Connect the lines and check for leaks.

Fuel Tubes—Plastic

CAUTION: Ford approved nylon fuel tubing is made from material which has been tested and proven to be acceptable for use with commercially available fuels. It is also resistant to most environmental conditions. Avoid using alternate tubing materials. Use of non-approved tubing could pose a hazard in service.

CAUTION: Plastic fuel tube must not be repaired using hose and hose clamps. Push connect fittings cannot be repaired except to replace the retaining clips. Should the plastic tubes, push connect fittings or mating tube ends become damaged and leak, approved service parts (Fig. 27) must be used to service the fuel lines.

The 7.3L diesel engine uses flexible fuel supply and return lines. These nylon lines replace most of the conventional steel tubing. The plastic fuel tube assemblies are secured to the body rails with clips.

CAUTION: The plastic fuel lines can be damaged by torches, welding sparks, grinding and other operations which involve heat and high temperatures. If any repair or service operation will be used which involves heat and high temperatures, locate all fuel system components, especially the plastic fuel lines to be certain they will not be damaged. It is recommended that the plastic fuel tubes be removed from the vehicle if a torch or high heat producing equipment is to be used for service in the following areas:

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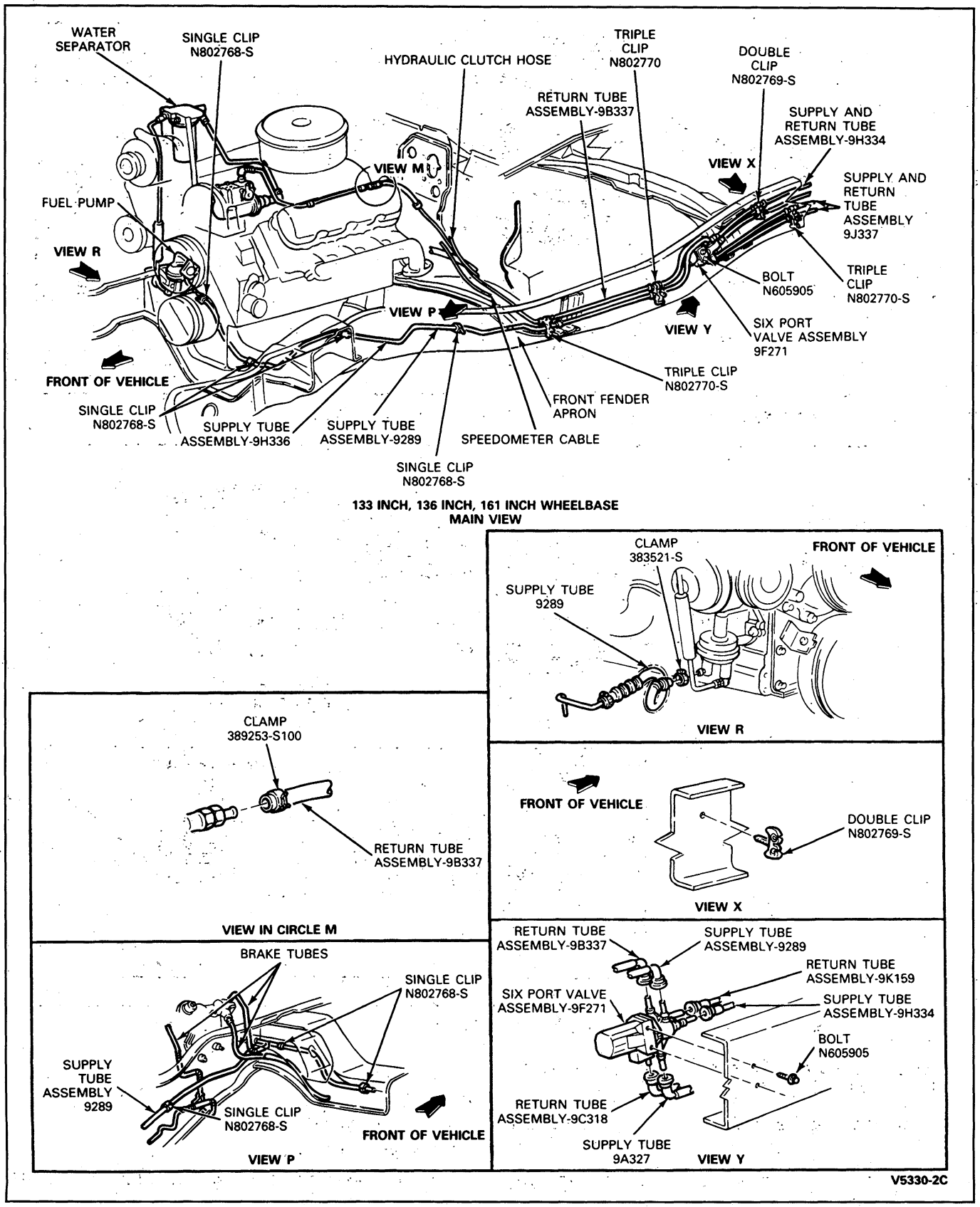


FIG. 6 Fuel Line Installation—Aft Axle Fuel Tank, 133 Inch Wheelbase—F-250—F-350

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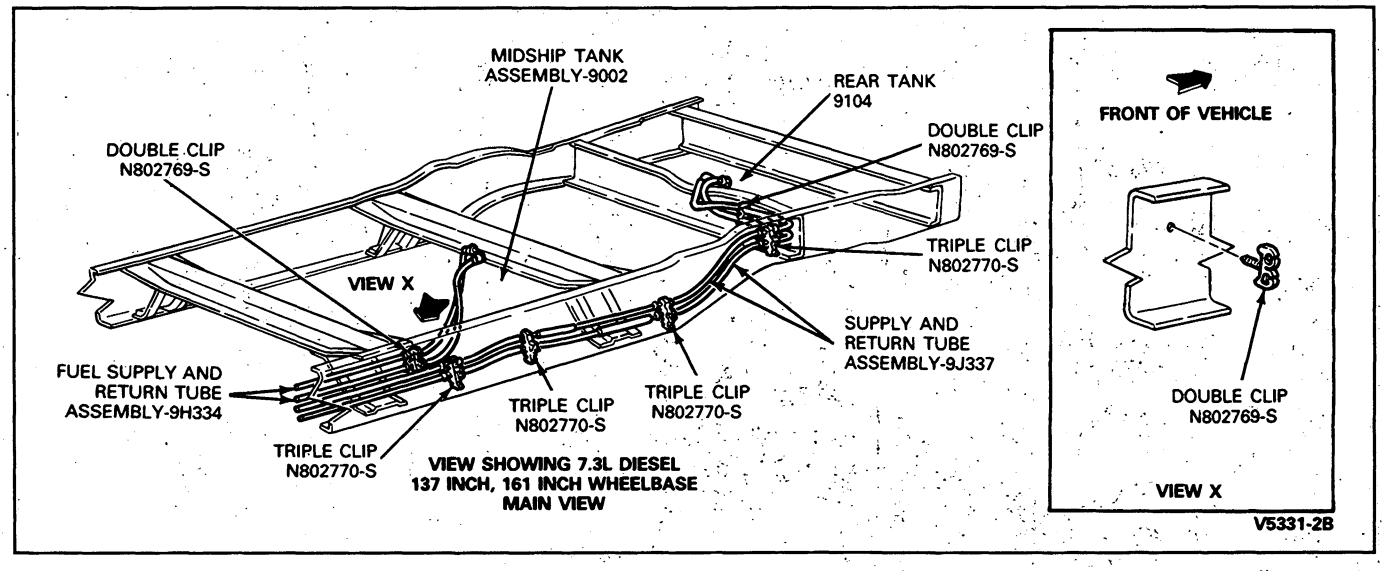


FIG. 7 Fuel Line Installation—Dual Fuel Tanks, 137, 161 Inch Wheelbase—F-250—F-350

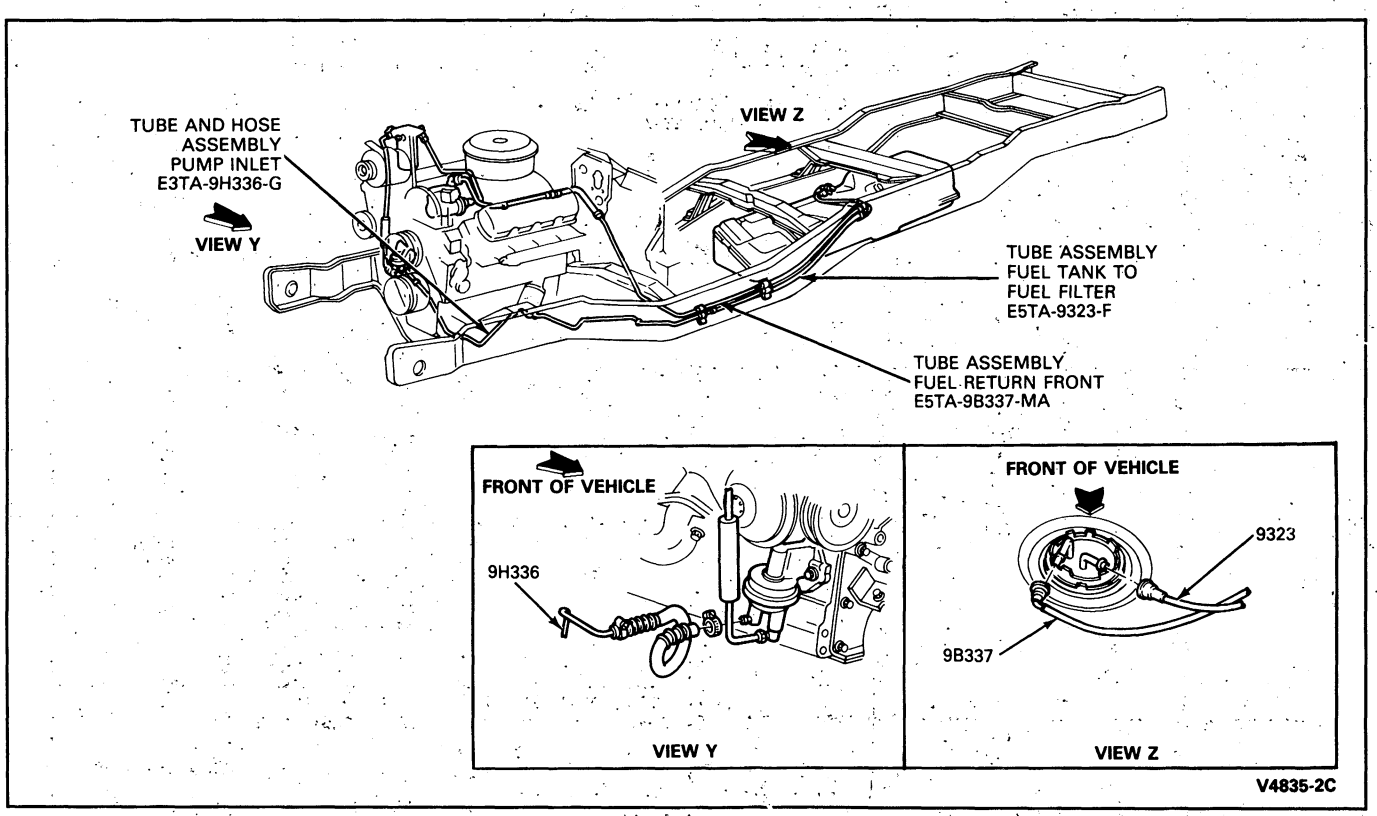


FIG. 8 Fuel Line Installation—Midship Fuel Tank, 137 Inch Wheelbase—F-250—F-350—F-Super Duty

1. Exhaust or suspension components in proximity to fuel tubes.
2. Underbody frames, rails and crossmembers (LH side).
3. Dash panel, under vehicle or inside the passenger compartment (lower LH side).

Fuel Tanks

F-250—F-350—F-Super Duty Chassis Cab and Commercial Stripped Chassis

Aft-Of-Axle Fuel Tank

Fuel tank installations are shown in Figs. 14, 15, 16 and 18.

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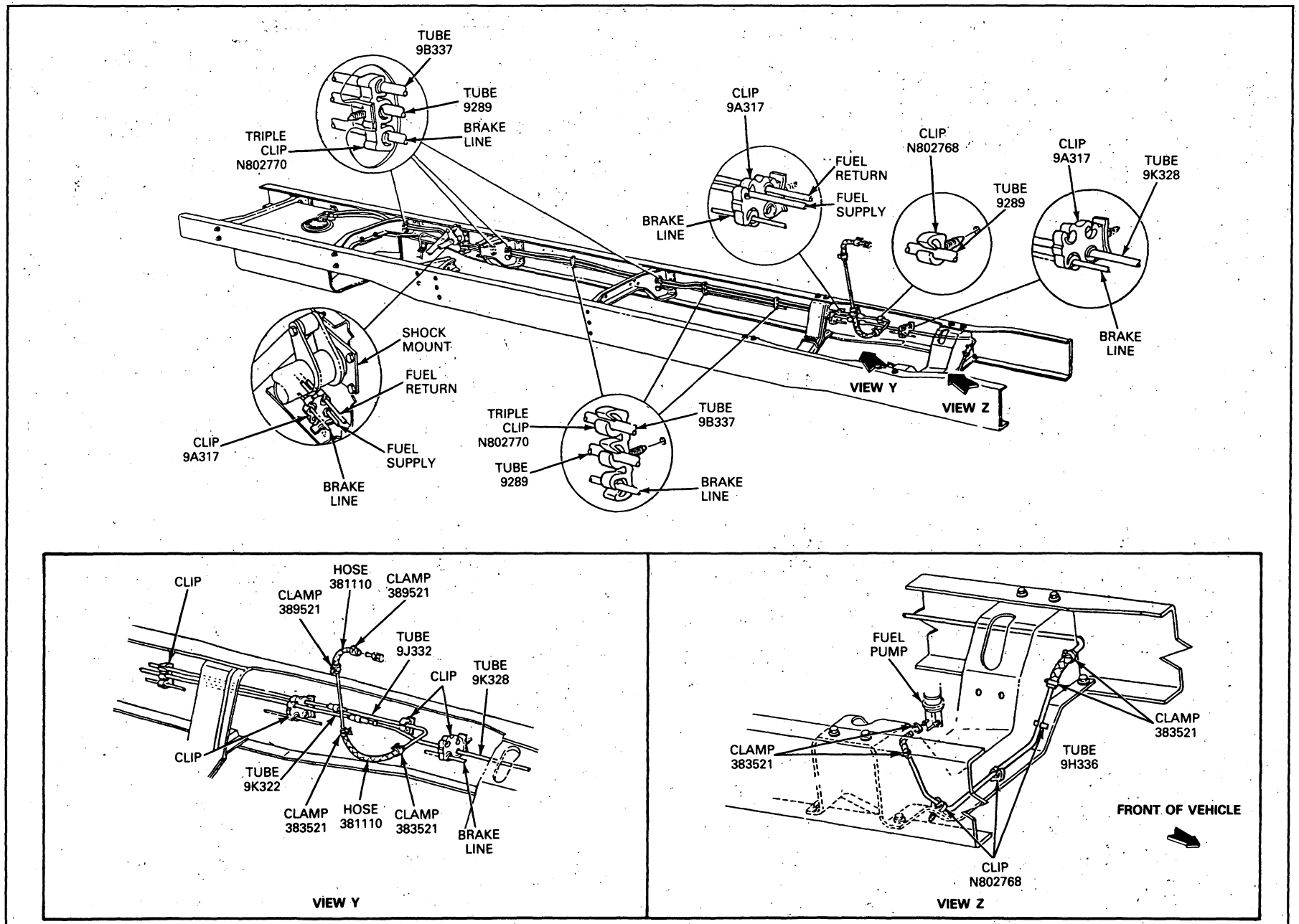


FIG. 9 Fuel Line Installation—Aft Fuel Tank—F-Super Duty Commercial Stripped Chassis Vehicles

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Removal

1. Raise the rear of the vehicle.
2. To avoid electrical sparking at the tank, disconnect the ground cables on both batteries. Then disconnect the fuel gauge sending unit wire at the fuel tank.
3. On vehicles with dual tanks, disconnect the ground wire after both tanks have been drained. Siphon the fuel from the tank into a suitable container at the hose between the fuel pump and the fuel tube.
4. If the fuel gauge sending unit is to be removed, turn the unit retaining ring counterclockwise and remove the sending unit, retaining ring and gasket.
5. Loosen the clamp on the fuel filler pipe at the tank and disconnect the filler pipe hose, pulling along the rubber inner tube from filler neck.
6. If removing the metal type tank, support the tank and remove the bolts attaching the tank supports to the frame. Carefully lower the tank. Finish removing the filler pipe and filler pipe vent hose if not possible in Step 5. Remove the tank under the vehicle.
7. If removing the plastic type tank, support the tank and remove the bolts attaching the combination skid plate and tank support to the frame. Carefully lower the tank. Complete removing the filler pipe if not possible in Step 5. Remove the skid plate and tank from under the vehicle. Disassemble the skid plate from the tank.

Installation

1. Install new support strap insulation as required.
2. If installing the plastic type tank, preassemble the skid plate and support straps to the tank (Figs. 15 and 16).
3. Raise the tank skid plate and support assembly and start the tank neck into the hose.
4. Position the tank assembly against the top straps or the frame and install the attaching bolts and nuts. Tighten the attaching bolts and nuts to 37-50 N·m (27-37 ft-lb).
5. Insert rubber inner tube inside filler neck and connect filler pipe hose. Tighten clamp to 3-4 N·m (27-35 in-lb).
6. If the fuel gauge sending unit was removed, make sure all the old gasket material has been removed from the unit mounting surface on the tank. Using a new gasket, position the fuel gauge sending unit to the fuel tank and secure with the retaining ring.

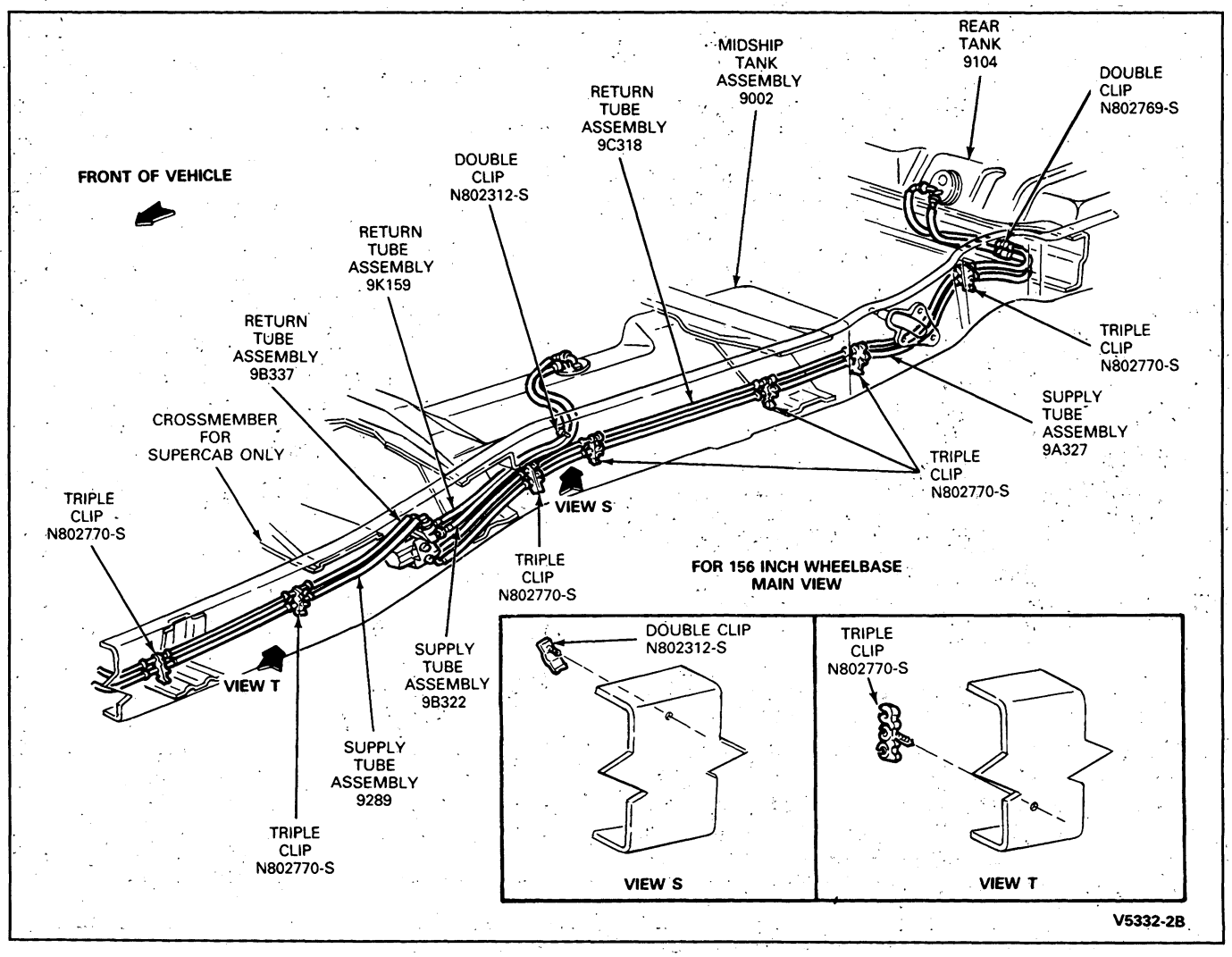


FIG. 10 Fuel Line Installation—Dual Fuel Tank, 155 and 133 Inch Wheelbase—F-250—F-350 Super Cab

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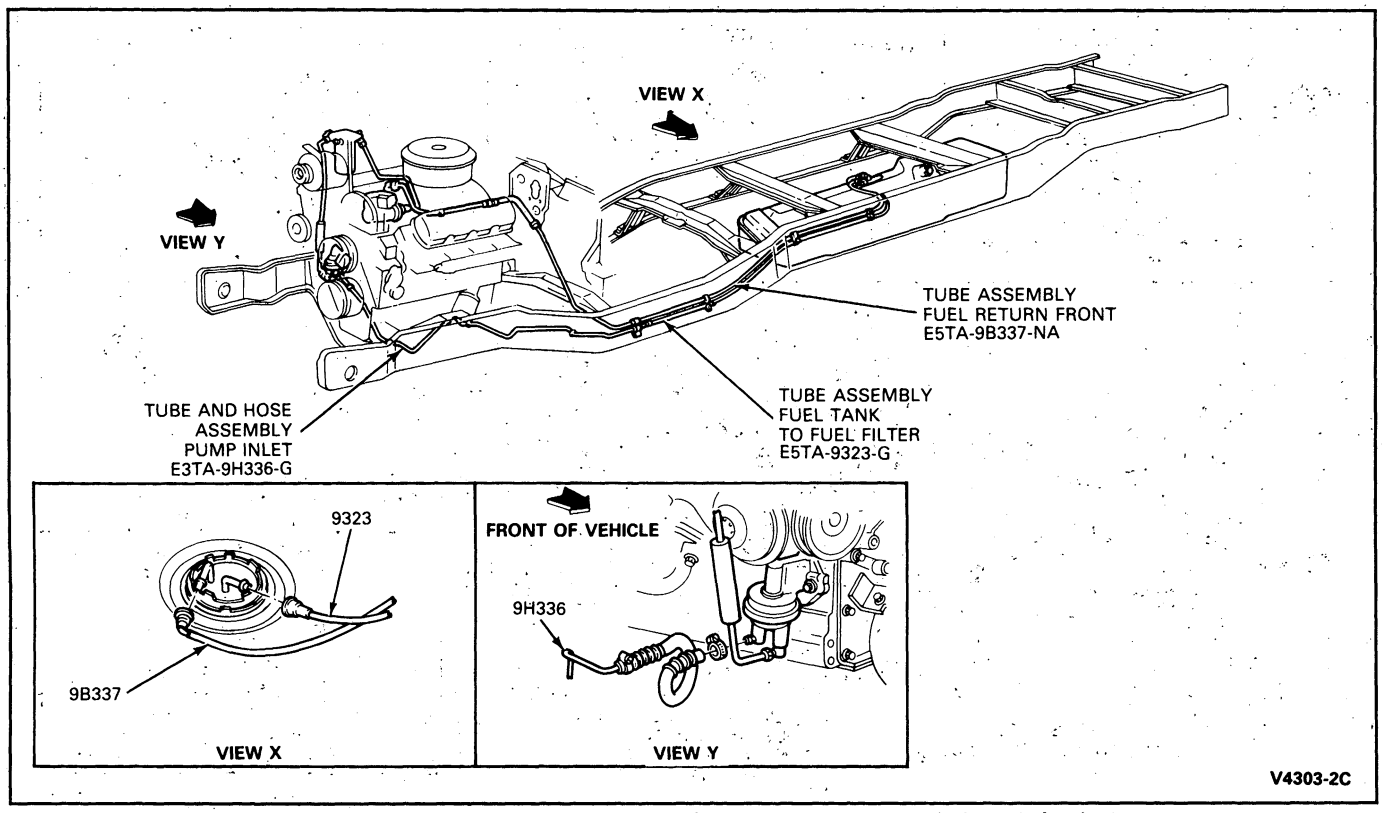


FIG. 11 Fuel Line Installation—Midship Fuel Tank, 161 Inch Wheelbase—F-250—F-350—F-Super Duty

7. Connect the fuel gauge sending unit wire to the sending unit.
8. Connect the fuel line at the fuel gauge sending unit and tighten the clamps securely. Install the drain plug, if so equipped. Fill fuel tank.
9. Connect both vehicle battery ground cables.
10. Fill the tank and check all connections for leaks.
11. Lower the vehicle.

Midship Fuel Tank—Plastic

Refer to Fig. 17.

Removal

1. Drain the fuel into a suitable container by siphoning through the fuel hose at the fuel pump-to-fuel tube connection.
2. To avoid electrical sparking at the tank, disconnect the ground cables on both batteries.
3. Remove skid plate and heat shields.
4. Disconnect the fuel gauge sending unit wire at the fuel tank.
5. Loosen fuel filler hose clamp at the tank and disconnect the fuel filler hose.
6. Disconnect the fuel tube push-connect fittings at fuel gauge sending unit.
7. Support the tank. Remove the bolts from the retaining straps and lower the tank to the floor.
8. To remove fuel gauge sending unit, rotate threaded retainer ring counterclockwise with Tool (TBD) or equivalent.
9. To remove vapor valve, pull it out of the grommet.
10. Replace any worn or damaged parts.

Installation

1. Position fuel gauge sending unit seal in groove. Then, position fuel gauge sending unit in tank and install threaded retainer ring with Tool (TBD) or equivalent. Tighten to 55-68 N·m (40.6-50.1 ft-lb).
2. Insert vapor valve into grommet.
3. Position tank in vehicle and secure retaining straps to frame with hand-started attaching bolts.
4. Position and secure fuel filler hose on fuel tank filler neck. Tighten hose clamp to 3-4 N·m (27-35 in-lb).
5. Clip vapor valve hose to frame rail.
6. Connect the fuel tubes and electrical connector to the fuel gauge sender unit.
7. Tighten strap attaching bolts to 16-24 N·m (11.8-17.7 ft-lb).
8. Position heat shield on fuel tank retaining strap studs and tighten attaching nuts to 8-11 N·m (5.9-8.1 ft-lb).
9. Position skid plate in vehicle and secure the skid plate and heat shield to frame with attaching bolts and nuts. Tighten to 8-11 N·m (5.9-8.1 ft-lb).
10. Position heat shield in vehicle and secure it to the frame and the heat shield with attaching bolts. Tighten to 8-11 N·m (5.9-8.1 ft-lb).
11. Connect battery ground cables at both batteries.
12. Fill the tank and check all connections for leaks.

Midship Fuel Tank—Steel

Typical fuel tank installations are shown in Fig. 19. Refer to the specifications for the capacities and usage.

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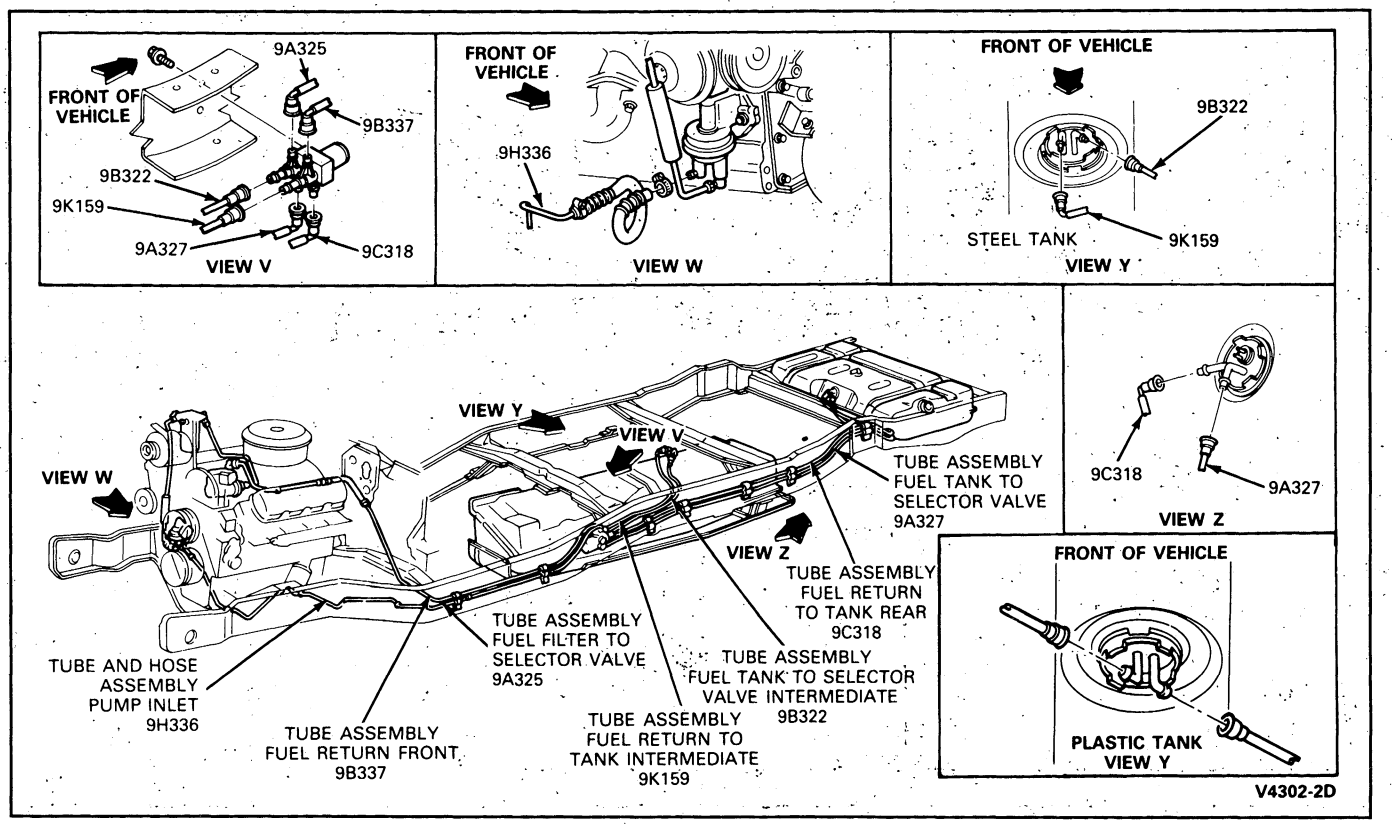


FIG. 12 Fuel Line Installation—Dual Fuel Tanks, 133 Inch Wheelbase—F-250—F-350

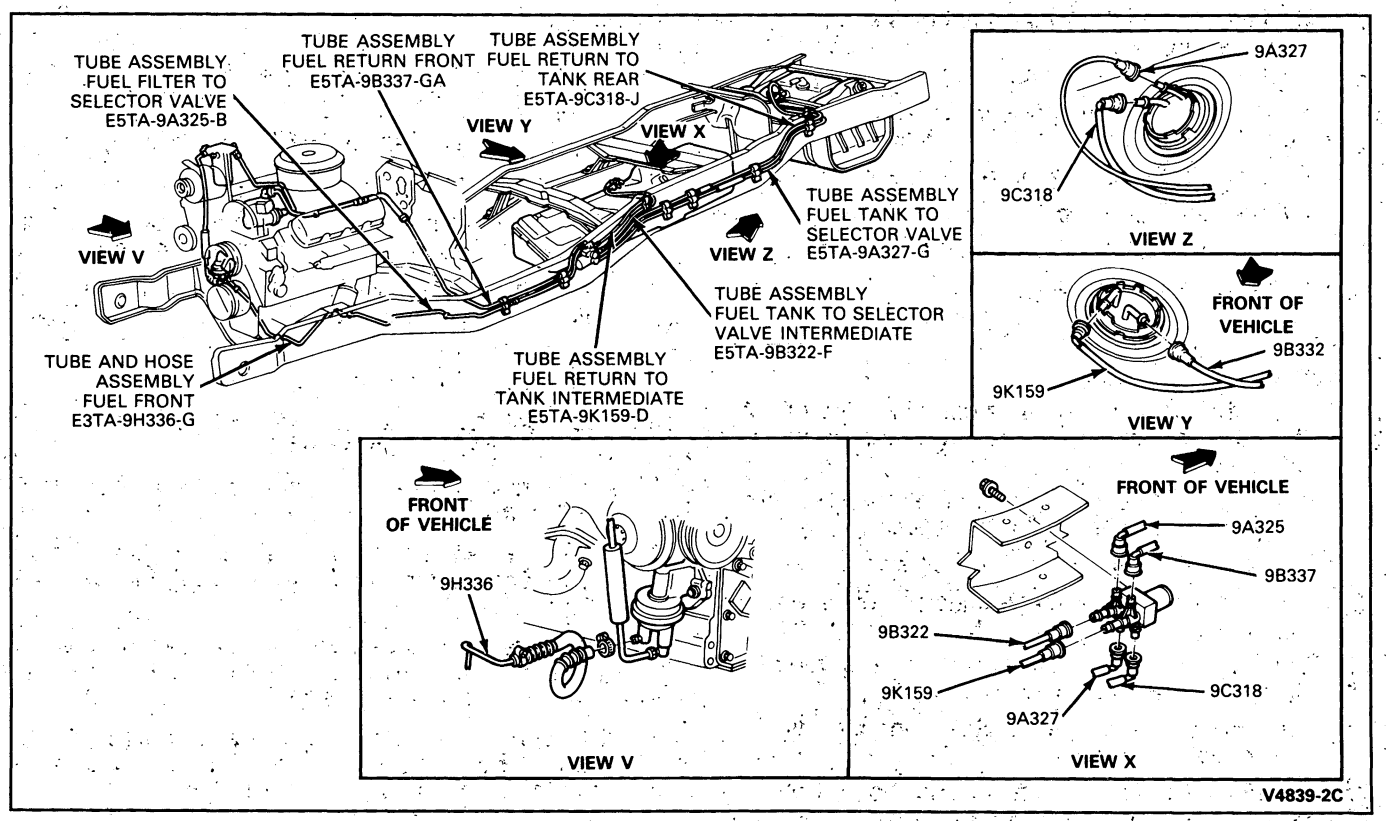


FIG. 13 Fuel Line Installation—Dual Fuel Tanks, 137 Inch Wheelbase—F-250—F-350

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Removal

1. Drain the fuel into a suitable container by siphoning through the fuel hose at the fuel pump-to-fuel tube connection.
2. To avoid electrical sparking at the tank, disconnect the ground cables on both batteries. Then disconnect the fuel gauge sending unit wire at the fuel tank.
3. On vehicles with dual tanks, disconnect ground wire after draining both tanks. Remove the clamps and disconnect the hoses attached to the fuel tank.
4. Support the tank, remove the nuts and bolts from the retaining straps, and lower tank to floor. Replace any worn or damaged parts.

Installation

1. Position retaining straps around fuel tank and attach bolts and nuts. Tighten to 30-41 N·m (22-30 ft-lb).
2. Insert rubber inner tubes inside filler necks and connect hoses to the tank. Tighten clamps to 3-4 N·m (27-35 in-lb).
3. Fill tank with fuel and connect both battery ground cables. Start the engine and check for leaks.

E-250, E-350

The E-250—E-350 fuel tank installations are shown in Figs. 20, 20A, 21 and 22.

Aft Axle Body—Mounted Tanks

Removal

1. Siphon the fuel from the tank by disconnecting the fuel supply line at the selector valve (dual tank vehicles) or at the connection to the steel fuel lines on the left frame rail ahead of the transmission.
2. To avoid electrical sparking at the tank, disconnect the ground cable on both vehicle batteries.
3. Raise the vehicle. Then, disconnect the fuel gauge sending unit electrical connector at the fuel tank.
4. Loosen the clamps on the fuel filler hose and vent hose at the tank neck. Disconnect the hoses from the tank.
5. Disconnect the fuel line push connect fittings as outlined.
6. Support the tank in position. Remove the nuts that attach the mounting straps to the "T" bolts.

   NOTE: The "T" bolts are attached to body brackets (located at the rear of the tank).

   Disengage the straps from the T-bolts and the front body brackets.
7. Lower the fuel tank and remove it from underneath the vehicle.
8. If the fuel gauge sending unit is to be removed, turn the unit retaining ring counterclockwise and remove the sending unit retaining ring and gasket.
9. If the vapor control valve is to be removed, pull it out of the seal located in the top of the tank and remove the seal.

Installation

1. If the fuel gauge sending unit was removed, scrape away the old gasket material from the mounting surface on the fuel tank. Using a new gasket, position the fuel gauge sending unit to the fuel tank and secure it with the retaining ring.

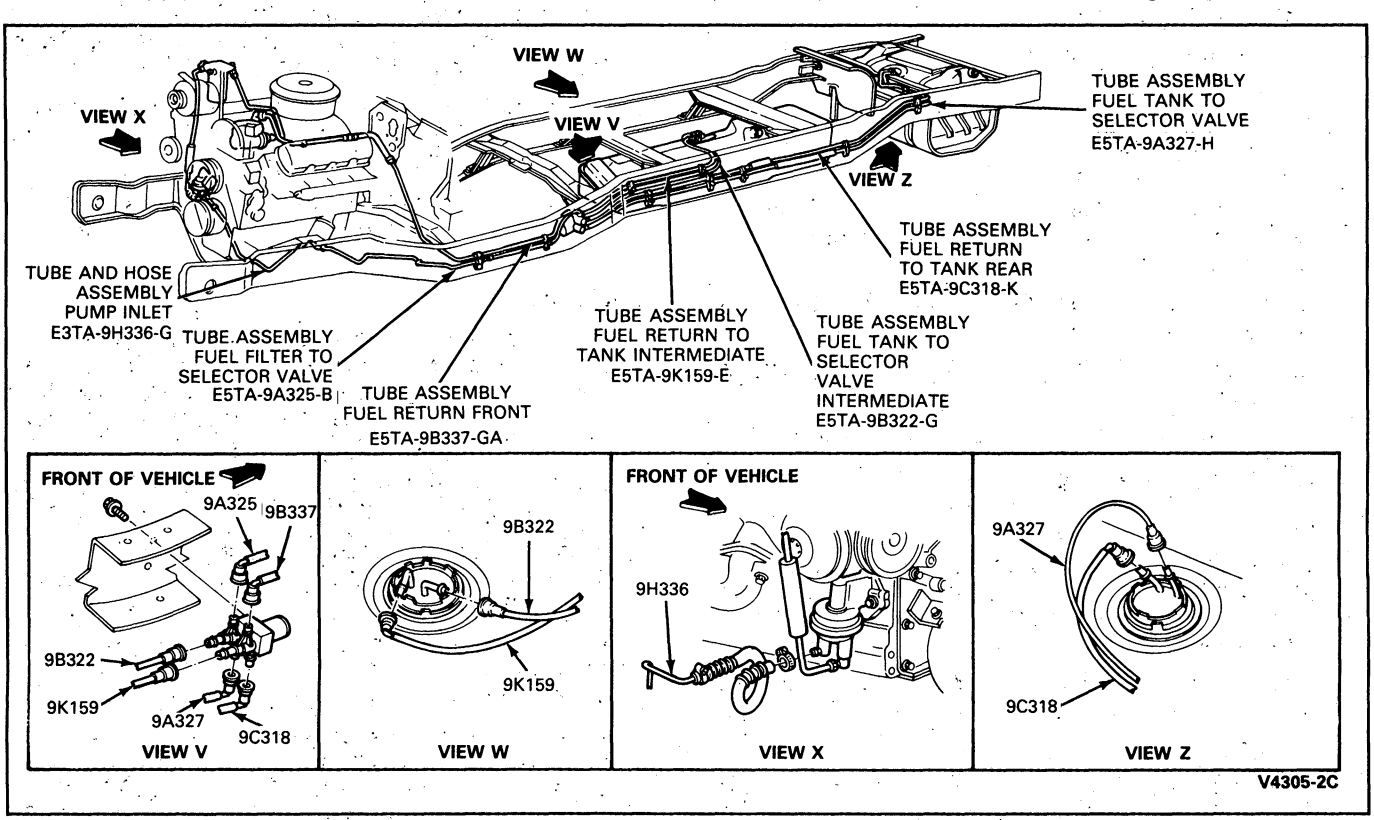


FIG. 14 Fuel Line Installation—Dual Fuel Tank, 161 Inch Wheelbase—F-250—F-350

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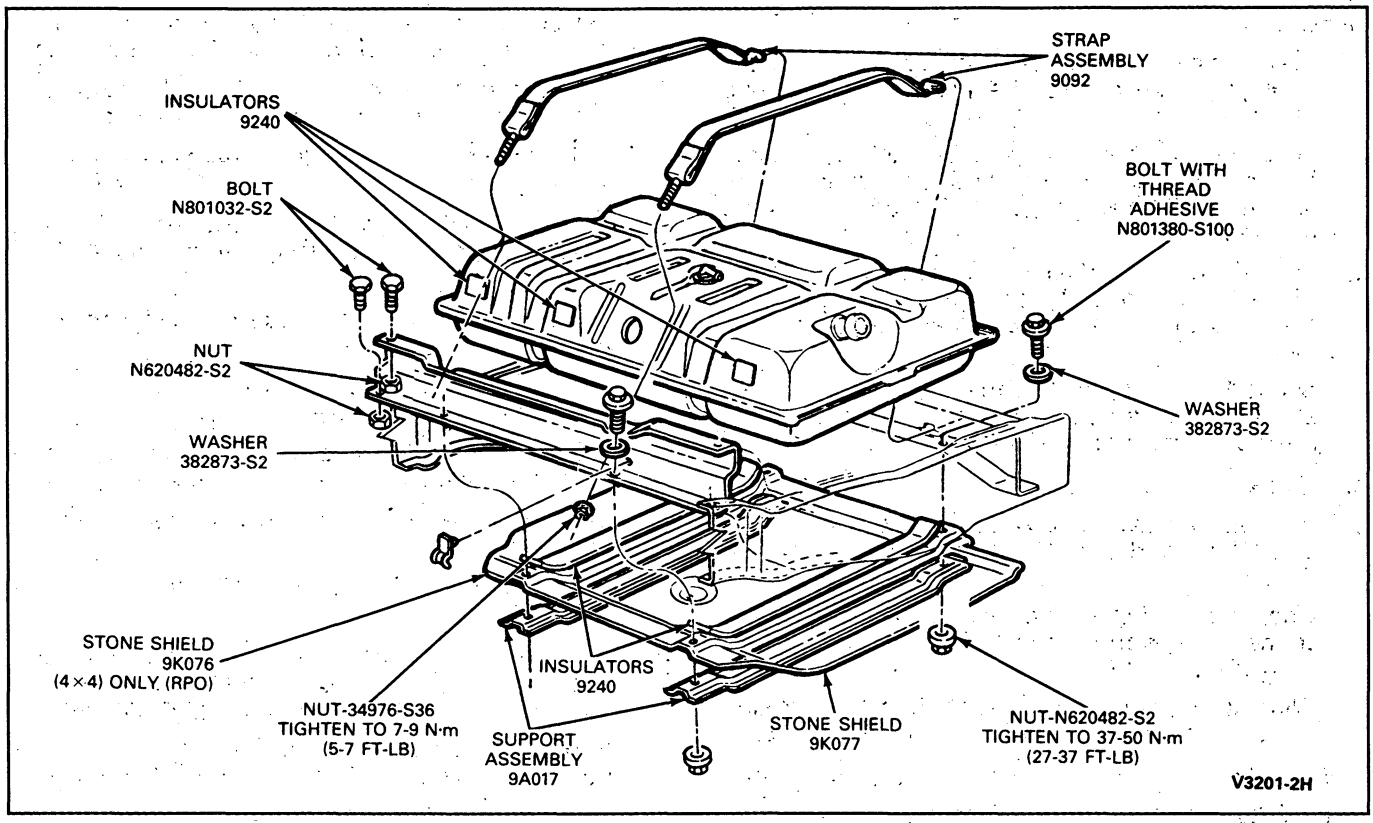


FIG. 15 Fuel Tank Installation—Steel Aft Fuel Tank—F-150—F-350—F-Super Duty

2. If the vapor control valve was removed, install the seal in the tank opening and press-fit the valve into place.
3. Attach the front ends of the mounting straps to the front body brackets.
4. Secure the strap ends to the T-bolts with the attaching nuts. Tighten nuts to 42-47mm (1.65-1.85 inches) of exposed thread length.
5. Connect the fuel lines to the fuel gauge sending unit as outlined.
6. Connect the fuel filler hose to the filler neck and vent neck at the tank. Tighten hose clamps to 3-4 N·m (25-35 in-lb).
7. Connect the fuel gauge sending unit electrical connector.
8. Lower the vehicle and connect both battery ground cables.
9. Fill the tank and check all connections for leaks.

Aft Axle Frame—Mounted Tank

Removal

1. Siphon the fuel from the tank by disconnecting the fuel supply line at the connection to the steel fuel lines on the left frame rail ahead of the transmission.
2. To avoid electrical sparking at the tank, disconnect both battery ground cables.
3. Raise the vehicle.
4. Loosen the clamps on the fuel filler hose and vent hose at the tank neck. Disconnect the hoses from the tank.
5. Disconnect the fuel line push connect fittings as outlined.
6. Support the tank in position. Remove the nuts and bolts that attach the tank supports to the frame. Disengage the straps from the front tank support and the rear crossmember. Lower the tank and remove it from underneath the vehicle.
7. If the fuel gauge sending unit is to be removed from the unit, remove the retaining bolts. Remove the sending unit and gasket.
8. If the vapor control valve is to be removed, pull it out of the seal located in the top of the tank, and remove the seal.

Installation

1. If the fuel gauge sending unit was removed, scrape away all the old gasket material from the mounting surface on the fuel tank. Using a new gasket, position the fuel gauge sending unit on the fuel tank and secure it with the retaining bolts.
2. If the vapor valve was removed, install the seal in the tank opening and press-fit the valve into place.
3. Raise the tank and attach the fuel sender electrical connector. Connect the fuel sender to the plastic fuel lines.
4. Attach the mounting straps to the crossmember in front of the tank with mounting bolts installed finger-tight.
5. Position the tank assembly against the top straps and insert the T-bolts into the rear crossmember. Tighten the T-bolt nuts to 27-34 N·m (20-25 ft-lb). Tighten the front bolts to 102-142 N·m (75-105 ft-lbs).

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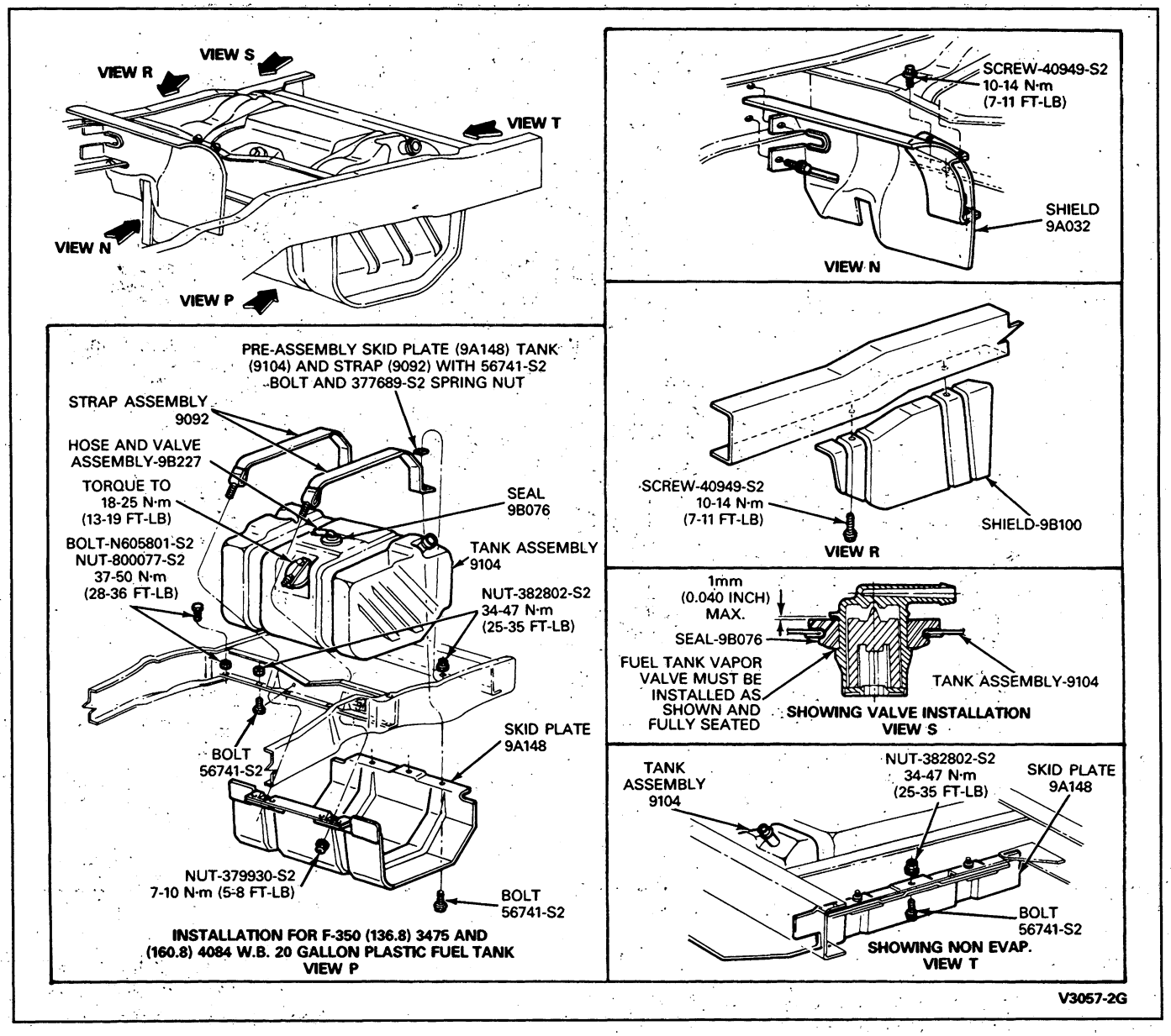


FIG. 16 Fuel Tank Installation—Plastic Aft Fuel Tank—F-250—F-350—F-Super Duty

6. Connect the fuel lines to the fuel gauge sending unit extension lines.
7. Connect the fuel filler hose to the filler neck and vent neck at the tank. Tighten the hose clamps to 3-4 N·m (25-35 in-lb).
8. Lower the vehicle.
9. Connect the vehicle battery ground cable removed in Step 2 of the removal procedure.
10. Fill the tank and check all connections for leaks.

Midship Tank

Removal

1. Siphon the fuel from the tank by disconnecting the fuel supply line at the selector valve.
2. To avoid electrical sparking at the tank, disconnect both battery ground cables from both vehicle batteries.
3. Raise the vehicle. Then, disconnect the fuel gauge sending unit connector at the fuel tank.
4. Support the tank in position. Disengage the mounting strap ends attached to the frame side rail. Remove the other end from the tank support by rotating the strap to disengage the "T" shaped hook end.
5. Lower the tank enough to gain access to the fuel fill and vent hoses, and fuel lines. Loosen the fuel fill and vent hoses and disconnect. Disconnect the fuel line push connect fittings as outlined.
6. Lower the tank and remove it from underneath the vehicle.
7. If the fuel gauge sending unit is to be removed, turn the retaining ring counterclockwise and remove the sending unit, retaining ring and gasket.
8. If the vapor control valve is to be removed, pull it out of the seal located on top of the tank and remove the seal.

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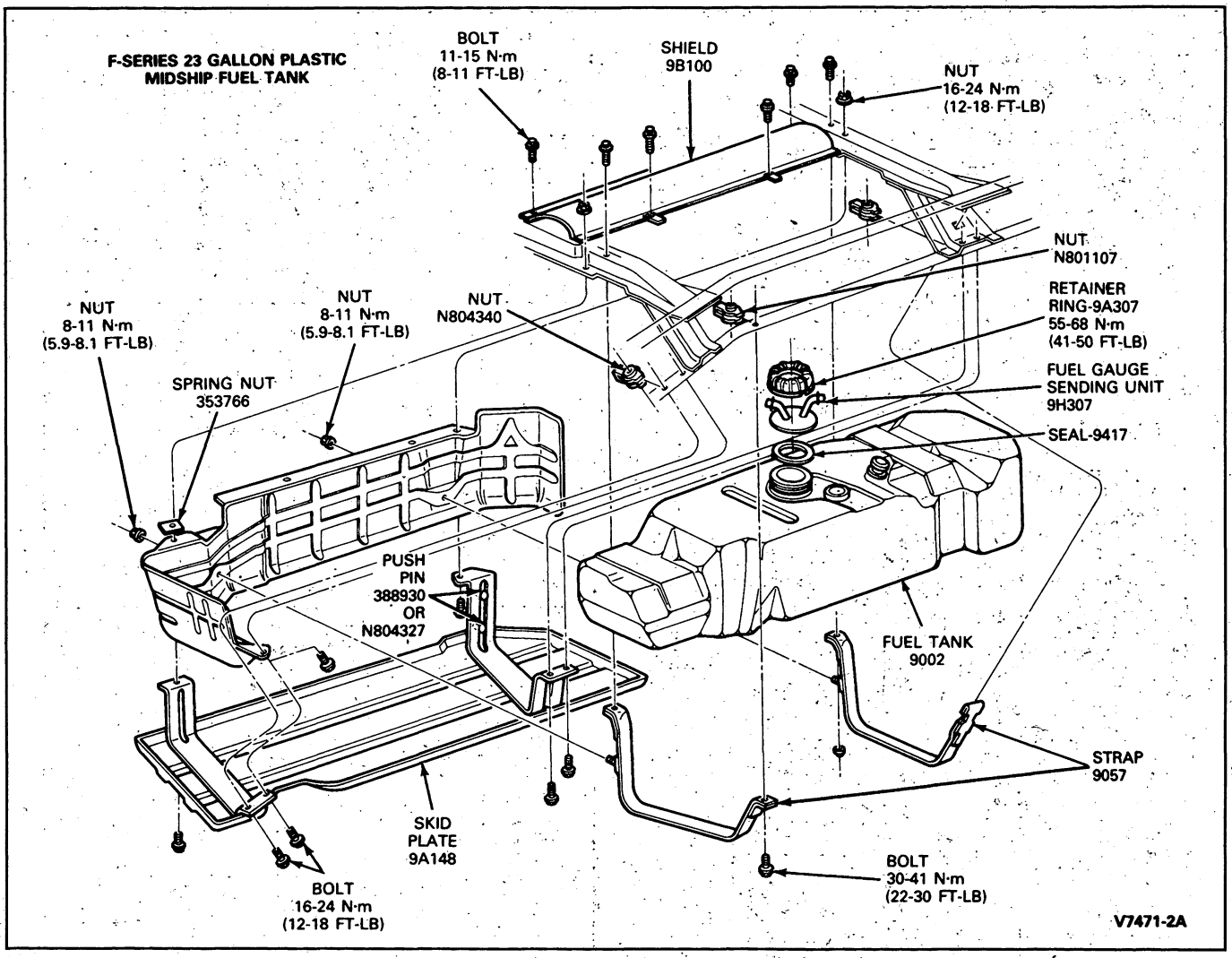


FIG. 17 F-Series 23 Gallon Plastic—Midship Fuel Tank

Installation

1. If the fuel gauge sending unit was removed, scrape away all the old gasket material from the mounting surface on the fuel tank. Using a new gasket, position the fuel gauge sending unit to the fuel tank and secure it with the retaining ring.
2. If the vapor valve was removed, install grommet in the tank opening and press-fit the valve into place.
3. If the insulation tape was worn or damaged, remove the material and install new pieces approximately 419mm (16.5 inches) long (two pieces).
4. Attach the "T" hook mounting strap ends in the tank supports. Raise the tank high enough and connect the fuel filler hose and fuel vent hose. Attach the plastic fuel lines. Tighten the clamps that attach the fill and vent hoses to the mating tank parts to 3-4 N·m (25-35 lb-in).
5. Attach the mounting straps stud end to the frame side rail with attaching nuts. Tighten to 32mm-38mm (1.25-1.50 inch) of exposed stud length.
6. Connect the fuel gauge sending unit connector at the fuel tank. Lower the vehicle.
7. Connect the vehicle battery ground cables removed in Step 2 of the removal procedure.
8. Fill the tank and check all connections for leaks.

Filler Pipes

F-250—F-350—F-Super Duty

Procedures are the same for aft axle and midship fuel filler pipes (Figs. 23, 24, 25 and 26).

Removal

1. Drain fuel to a level (approximately 3/4 full) below fuel tank filler connection by using the fuel hose at the fuel pump-to-fuel tube connection.
2. Loosen clamp attaching filler pipe hose to fuel tank filler neck. Disconnect filler pipe hose, pulling along rubber inner tube from filler neck.
3. Remove three retainer screws that attach filler pipe neck to body fuel filler housing.
4. Remove fuel filler pipe from vehicle.
5. Remove hose and clamps. Replace all worn or damaged parts.

Installation

1. Position fuel filler pipe in vehicle.

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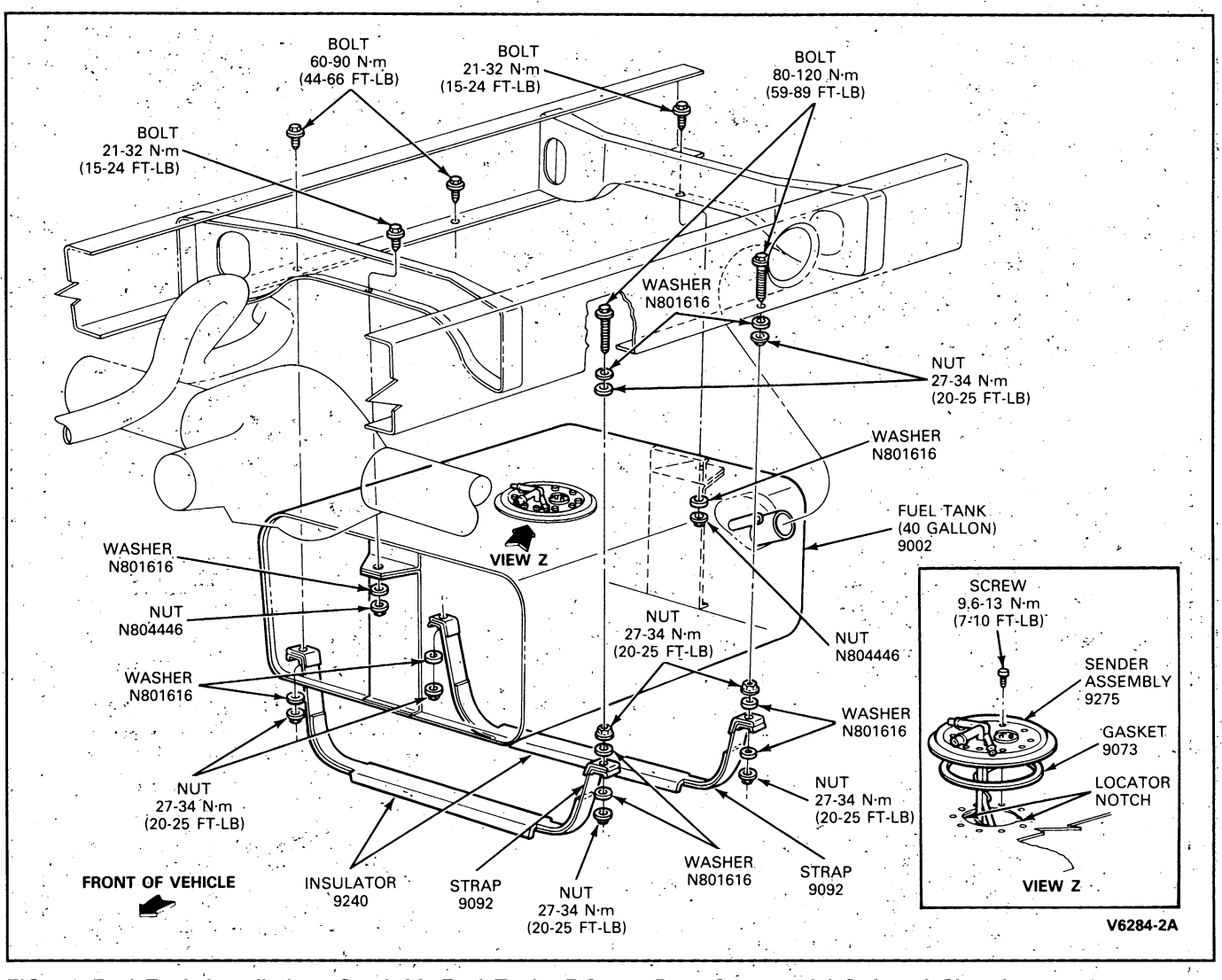


FIG. 18 Fuel Tank Installation—Steel Aft Fuel Tank—F-Super Duty Commercial Stripped Chassis

2. Position clamp on filler pipe hose-to-filler pipe neck connection and insert rubber inner tube in filler neck.
3. Install three retainer screws attaching filler pipe neck to body fuel filler housing. Tighten to 2-3 N·m (15-25 in-lb).
4. Adjust hose to obtain snug filler pipe installation. Tighten hose clamps to 3-4 N·m (25-35 in-lb). Make certain clamps are forward of flange on filler pipe to ensure a leakproof connection.
5. Fill tank with fuel. Install filler cap and check for leaks.

E-250—E-350

The procedures are the same for both aft axle and midship filler pipe assemblies (Fig. 26).

Removal

1. Siphon the fuel from the tank by disconnecting the fuel supply line at the selector valve (dual tank vehicles) or at the connection to the steel fuel lines on the left frame rail ahead of the transmission.
2. Remove the three retainer screws that attach the filler pipe flange to the body fuel filler pipe housing.
3. Loosen the clamps that attach the filler pipe to the fuel filler hose and the fuel vent hose. Disconnect the hoses.
4. Loosen the clamp that attaches the filler pipe to the support bracket at the underbody flange (if present).
5. Remove the fuel filler pipe assembly by rotating it through the opening in the underbody below the body housing assembly.

Installation

1. Install the fuel filler pipe assembly by inserting it through the underbody opening and rotating it to butt the pipe flange against the body side panel bracket.
2. Attach the pipe flange to the body side panel bracket with three retaining screws. Tighten screws to 3-4 N·m (25-35 in-lb).
3. Tighten the clamps that attach the filler pipe to the support bracket at the underbody flange to 3-4 N·m (27-35 in-lb.) (if present).
4. Connect the fuel filler hose and the fuel vent hose to the fuel filler assembly. Tighten the attaching clamps to 3-4 N·m (25-35 in-lb).

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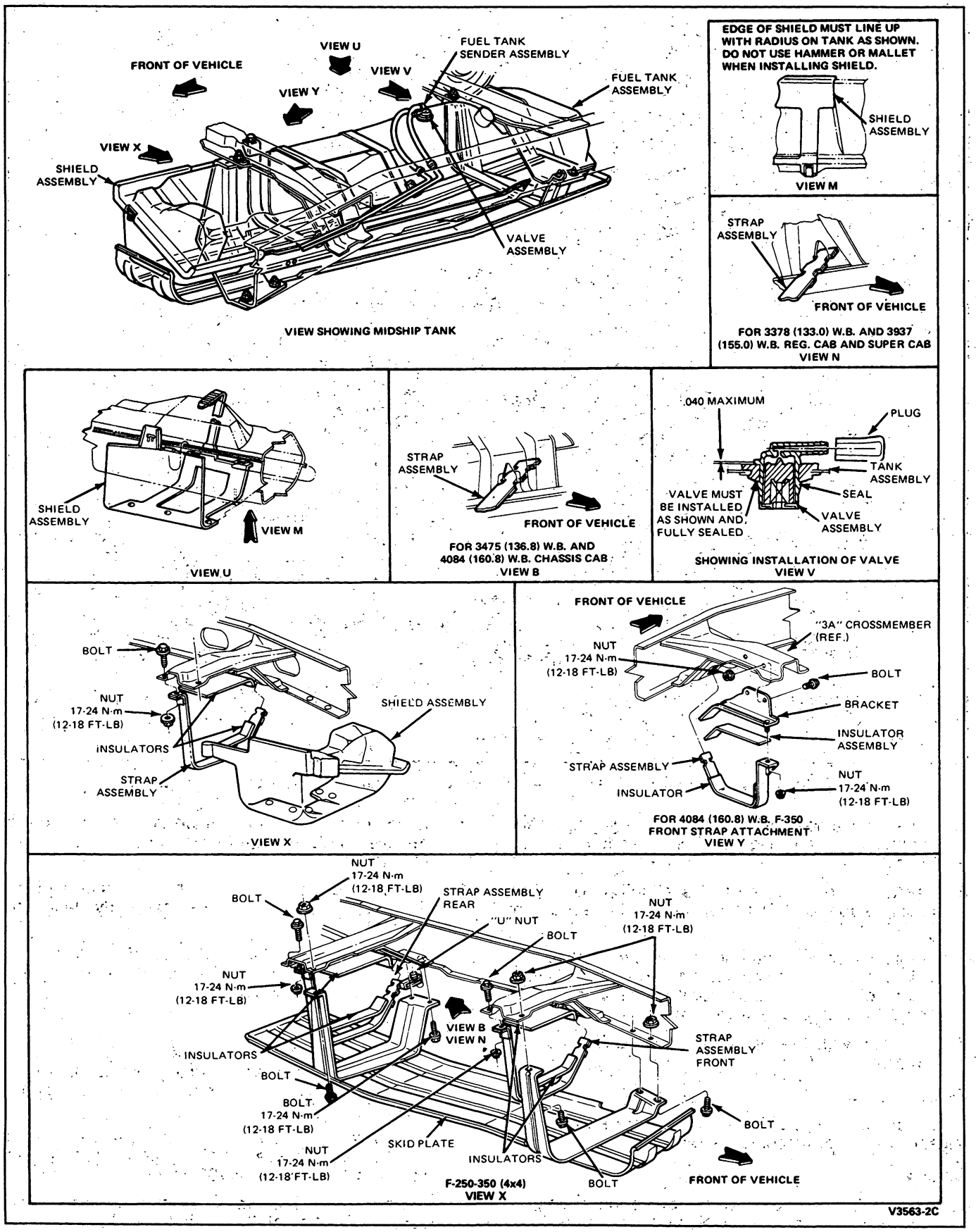


FIG. 19 Fuel Tank Installation—Midship 19 Gallon Steel Fuel Tank—F-250—F-350—F-Super Duty

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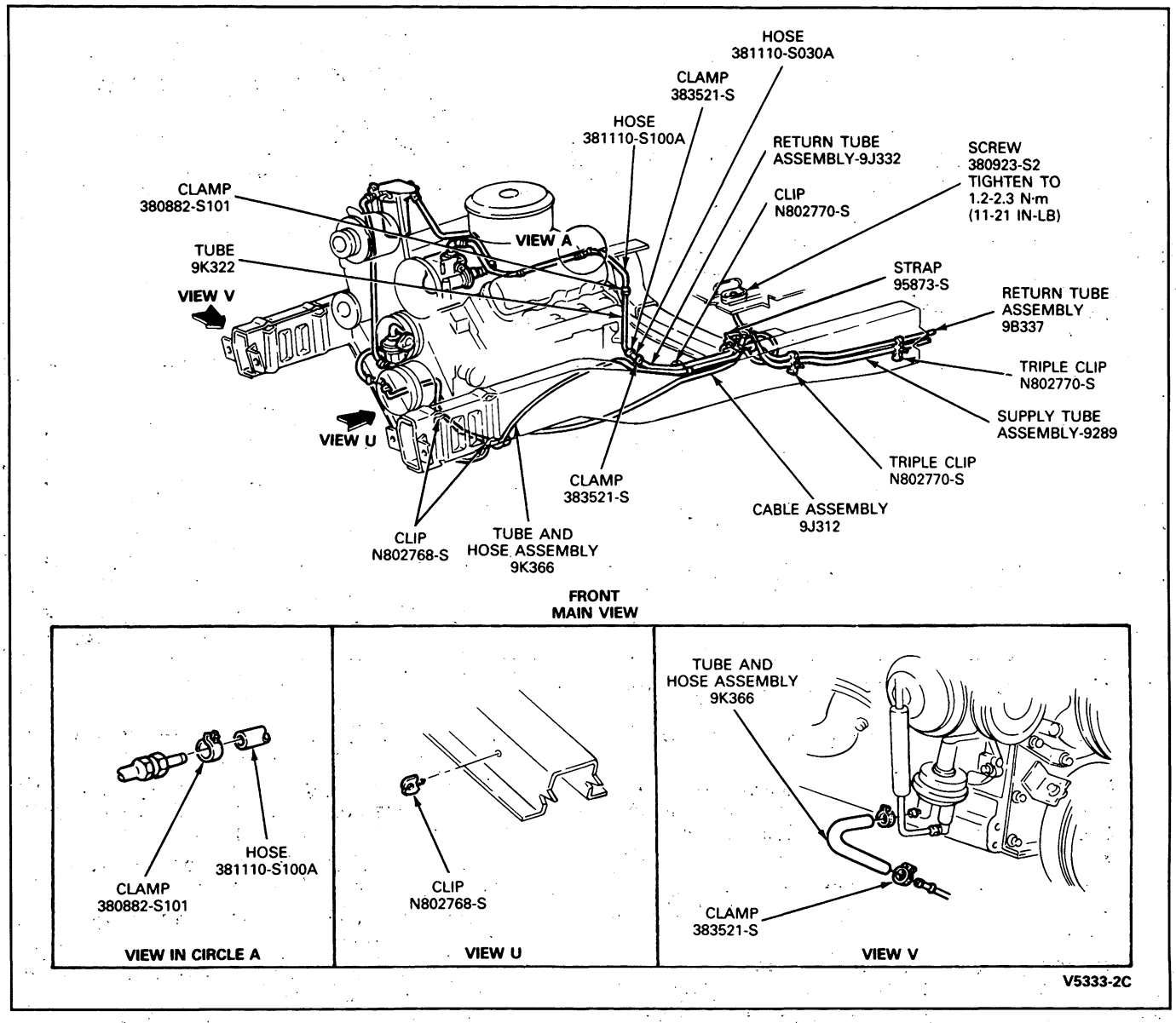


FIG. 20 Fuel System—Aft Axle Tank—E-250—E-350

5. Fill the tank, install fuel filler cap and check all connections for leaks.

Selector Valve—Auxiliary Fuel Tank

F-250—F-350 and E-250—E-350

Removal and Installation

1. Remove the fuel lines from the valve as outlined.
2. Remove electrical connector.
3. Remove the two bolts mounting the selector valve (Fig. 1).
4. To install, reverse Steps 1, 2 and 3.

NOTE: Ensure mounting bolts are tightened to 20-27 N·m (15-20 ft-lb).

Major Service Operations

Fuel Tanks

Fuel tanks do not require special service procedures and may be steam-cleaned and/or serviced using standard procedures. After steaming, allow them to thoroughly air dry. The vapor separator assembly should be replaced. Replace fuel tank strap bolts. Remove fuel sending unit when cleaning tank.

Fuel Lines

Vehicles equipped with nylon fuel tubes and push connect fittings have three types of service that can be performed on the fuel lines: replacing nylon tubing (splicing nylon to nylon), replacing push connector fittings, and replacing damaged push connect tube end.

Splicing Nylon to Nylon

1. Cut out damaged section of tubing and retain as a guide.
2. Cut a section of service tubing (type 11 or 12 nylon available in 9.5mm (3/8 inch), 7.9mm (5/16 inch) sizes) to the same length as the damaged section of tubing.
3. Select the proper 9.5mm (3/8 inch), 7.9mm (5/16 inch), barbed connectors for completing the splice.

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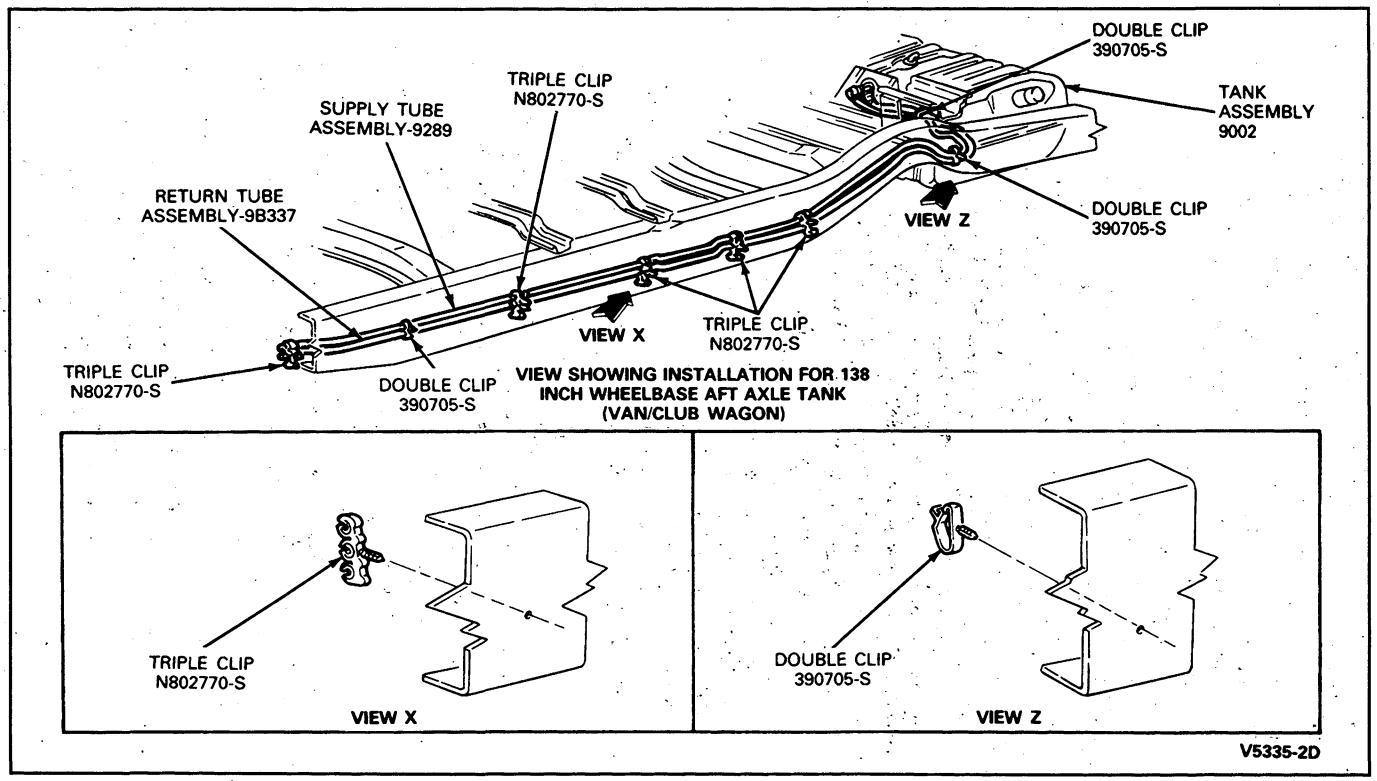


FIG. 20A Fuel System—Aft Axle Tank, E-250—E-350 (Cont'd)

Two connectors are required for each splice (Fig. 28).

NOTE: The connectors may be easily inserted into the nylon lines using Plastic Fuel Line Connector Tool 134-00001 or equivalent. Refer to Fig. 27 for all splicing service combinations.

4. Install the barbed connectors into each end of the replacement tubing using Tool 134-00001 or equivalent.
5. Install clips onto any tubes which might be difficult to access once the final splices are completed.
6. Complete the splice of the replacement nylon to the original nylon tubing at both ends.
7. Install any remaining clips which were removed for this service and check that the tubes are secure in the original clips.
8. Start engine and check for leaks.

Replacing Damaged Push Connectors

NOTE: Damaged push connectors must be discarded and replaced with new push connectors. If only the retaining clip is damaged, replace the clip.

1. Disconnect the damaged push connector. Be sure to bend the shipping tab to the side before removing retaining clip.
2. Select the proper size replacement push connector and nylon tube assembly (Fig. 27). In some cases the connectors will not be available with a tube attached. In this event, bulk tubing can be attached to the connector barbed and using the Rotunda Tool 134-00001 mentioned below.
3. Cut out a section of the original nylon tube to the same length as the nylon tube attached to the new push connector.
4. Install proper barbed connector into the replacement nylon assembly.

   NOTE: The connectors may be easily inserted into the nylon lines using Plastic Fuel Line Connector Tool 134-00001 or equivalent.
5. Complete the splice by connecting the barbed connector to the original nylon.
6. Connect the new connector assembly to the mating tube end.
7. Check that the underbody clips are properly securing the fuel tubes.
8. Start engine and check for fuel leaks.

Replacing Damaged Steel Push Connect Tube Ends

1. Using a tube cutter, remove the damaged push connect tube end at a convenient distance from the end.

   NOTE: Allow for adequate room to tighten a union with a wrench at this location.
2. Choose a proper replacement push connect tube end (Fig. 27).
3. If required, form the new tube end to the same shape as the damaged tube end which was removed.
4. Select the proper size union and attach the new steel tube end to the original tube.
5. Clean off the steel tube end and replace the push connector onto the tube. (A new retainer clip is recommended.)
6. Check that the underbody clips are properly securing the fuel tubes.
7. Start engine and check for leaks.

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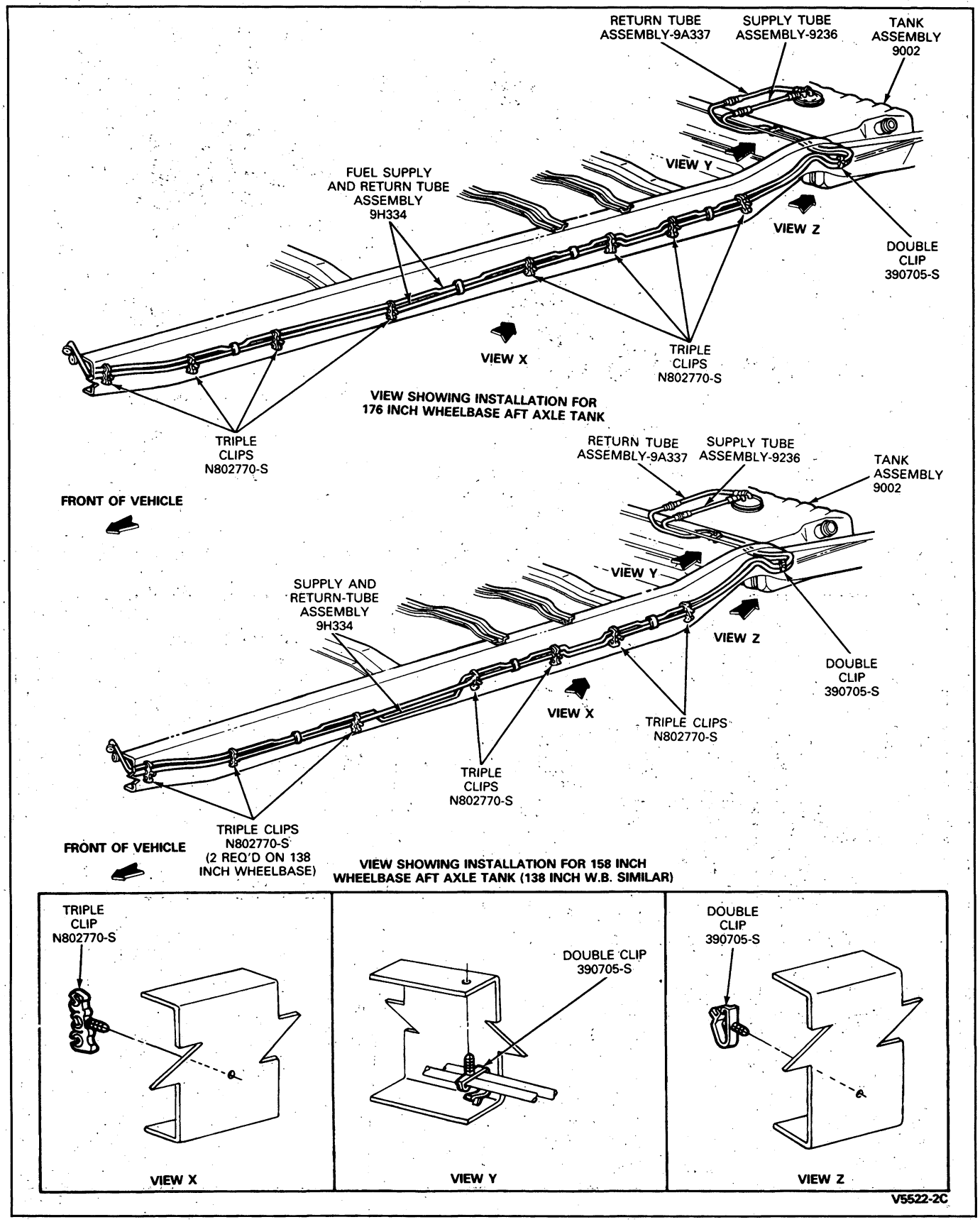


FIG. 21 Fuel System—136 Liter (36 Gallon) Aft Axle Tank, E-250—E-350 Cutaway

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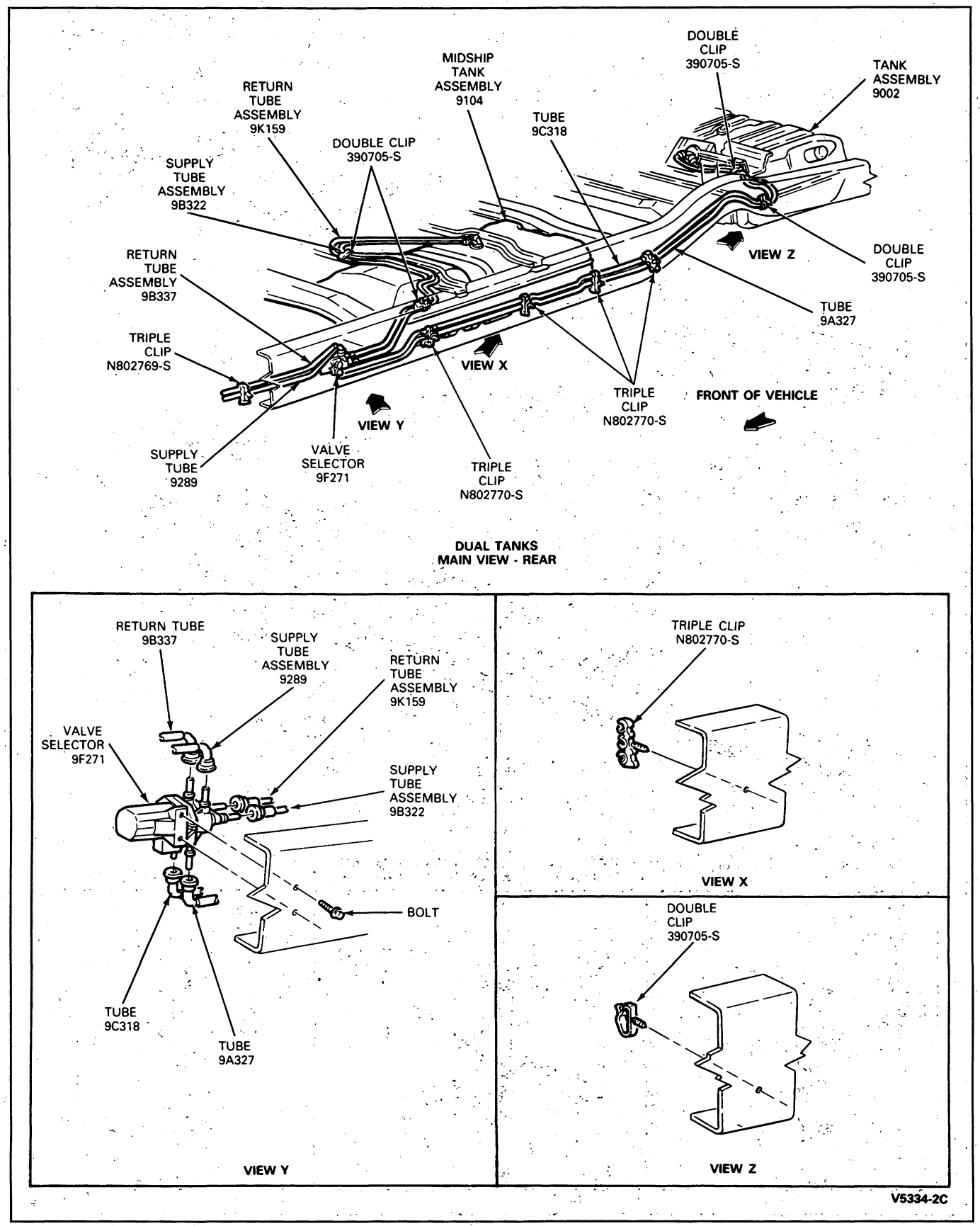


FIG. 22 Fuel System—Dual Tanks—E-250—E-350.

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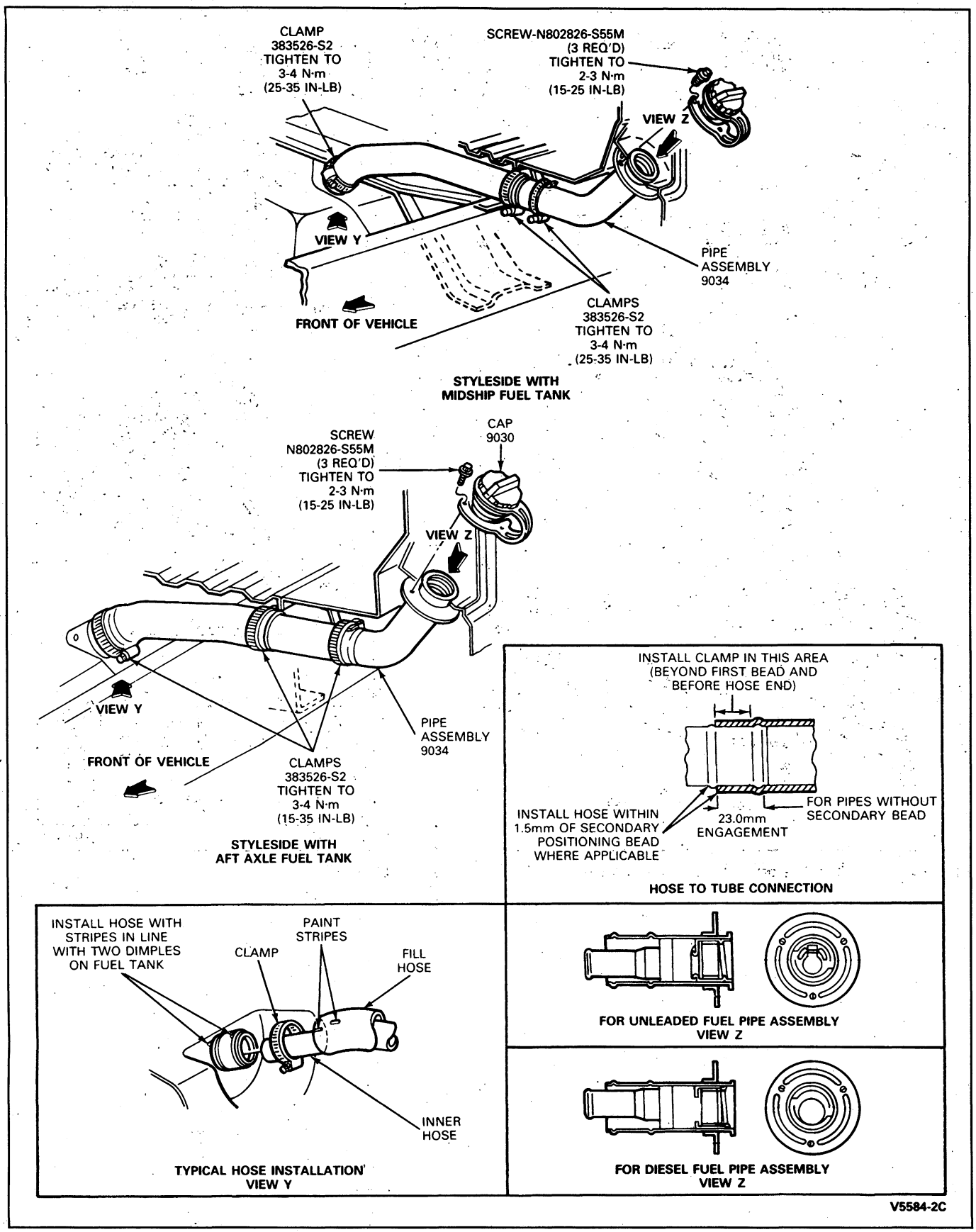


FIG. 23 Fuel Filler System Installation—Single Rear Wheel F-250—F-350

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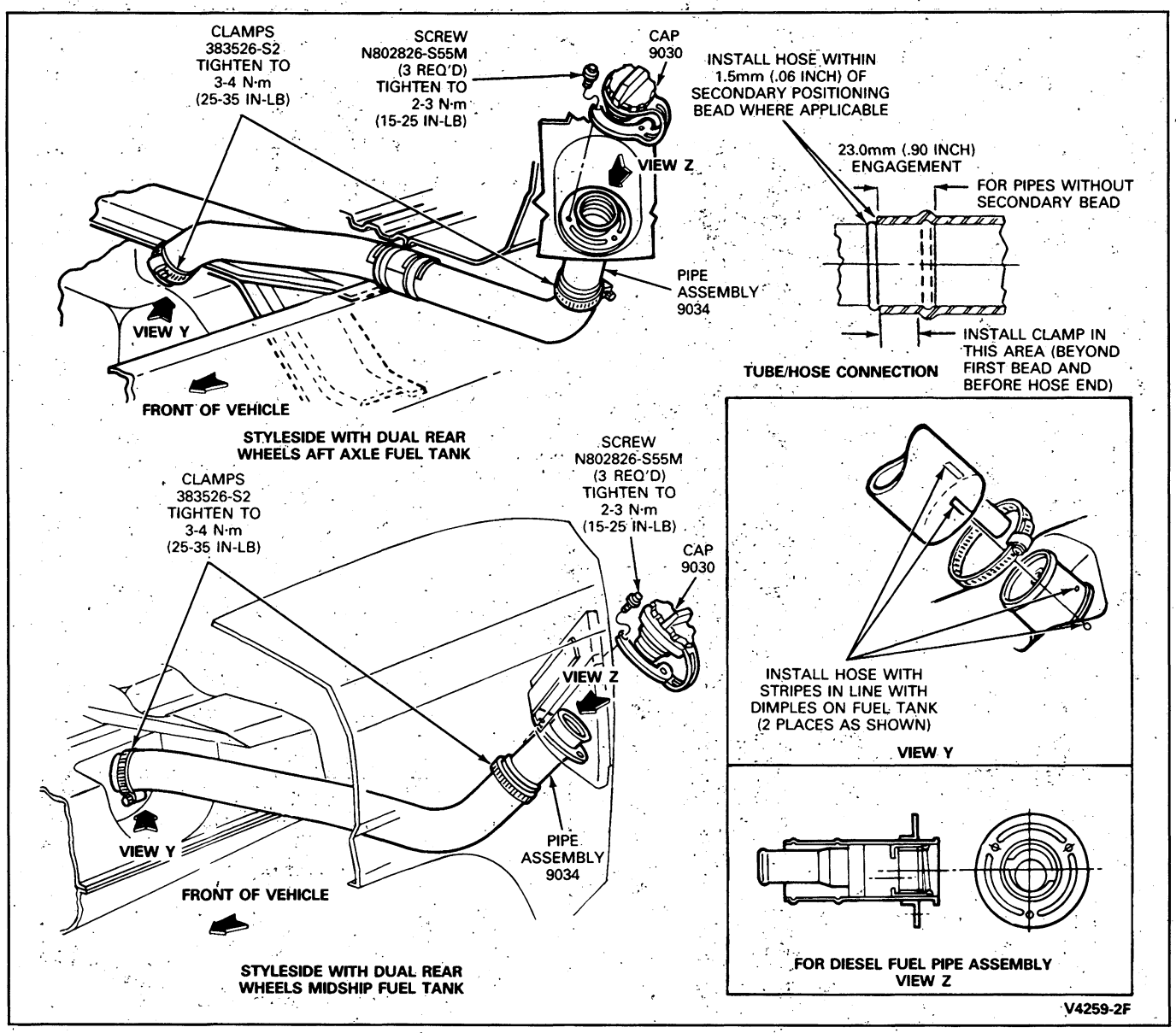


FIG. 24 Fuel Filler System Installation—Dual Rear Wheel Styleside F-250—F-350

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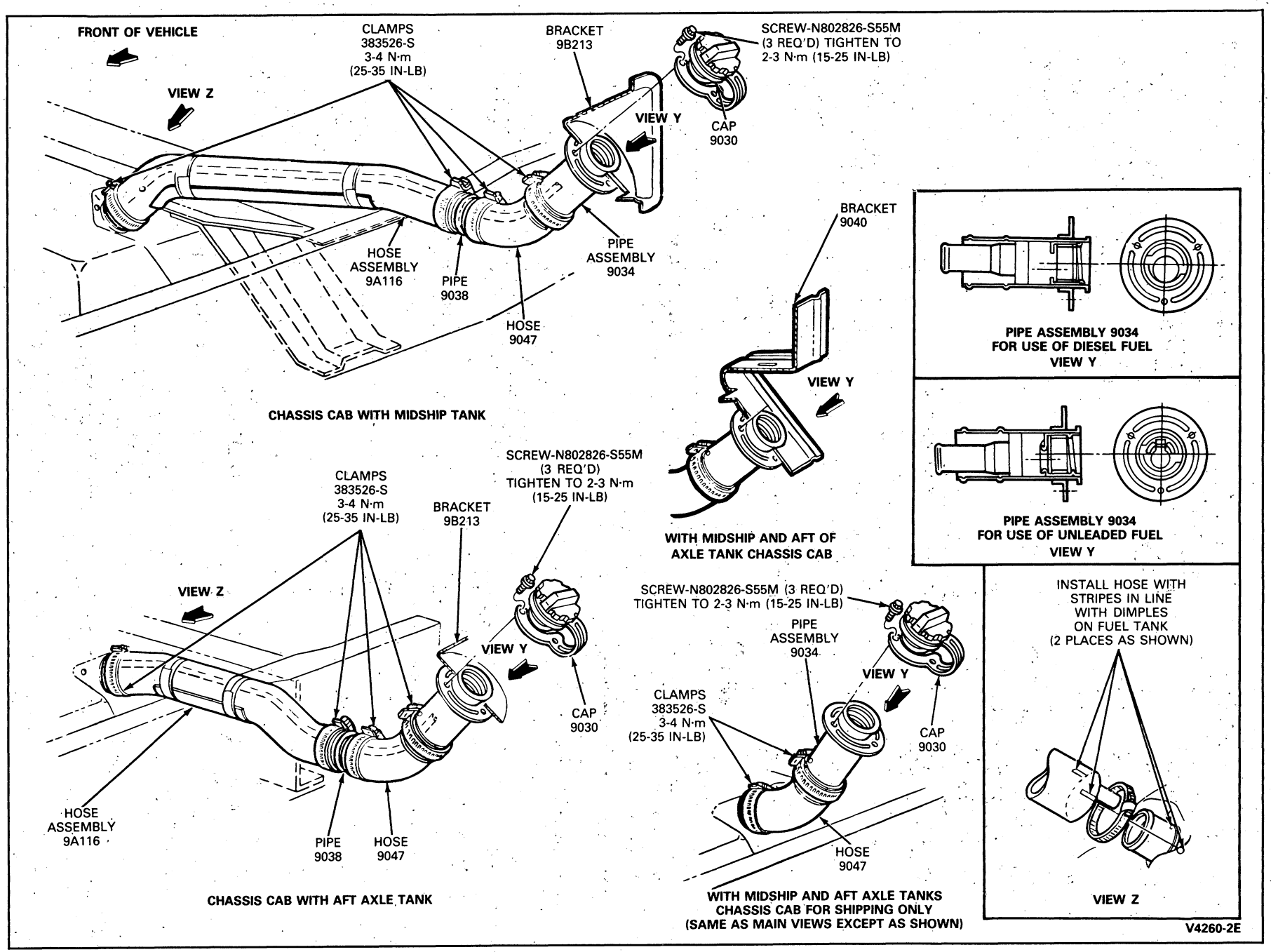


FIG. 25 Fuel Filler System Installation—F-Series Chassis Cab

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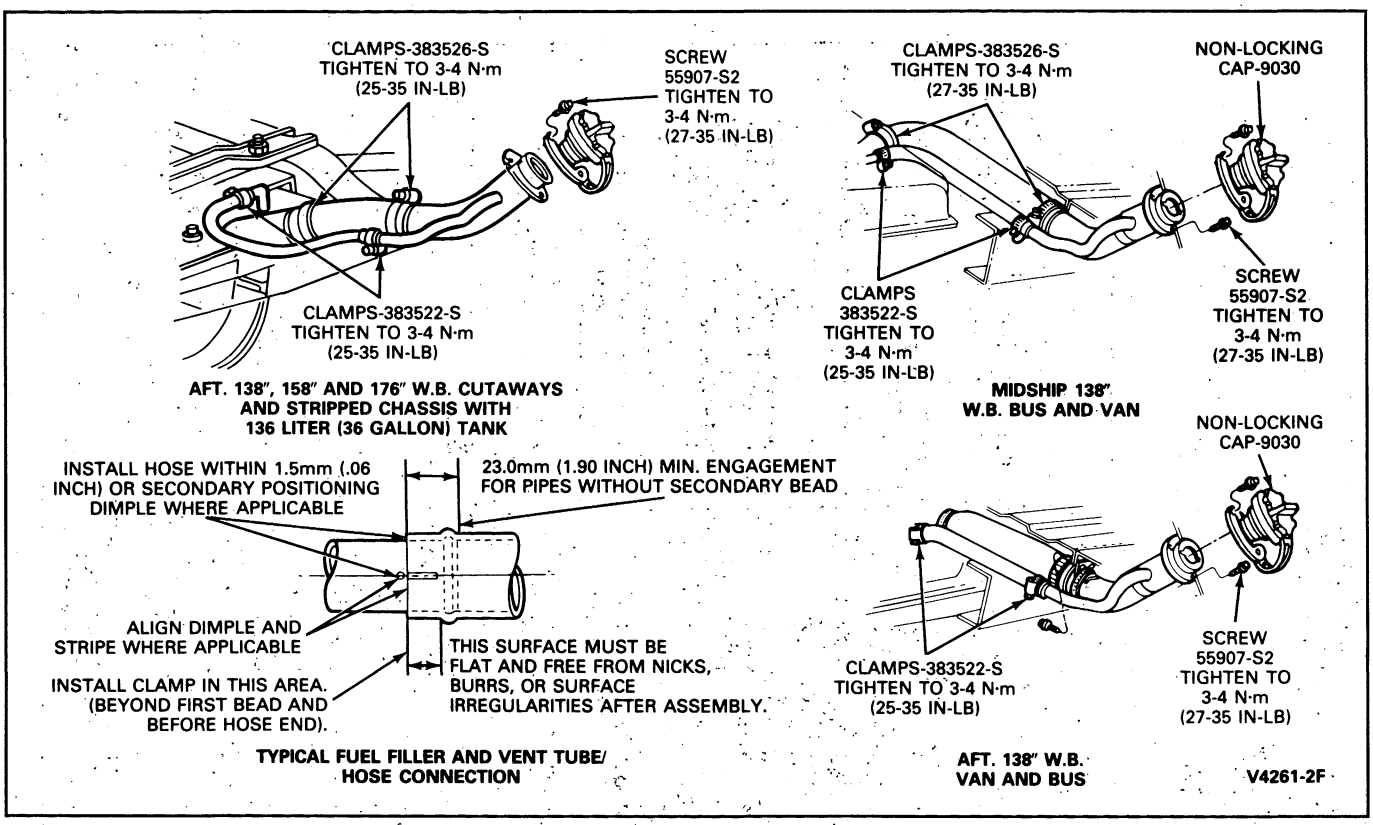


FIG. 26 Fuel Filler System Installation—E-250—E-350 (Midship and Aft Tank) and F-Super Duty Commercial Stripped Chassis with 40 Gallon Tank

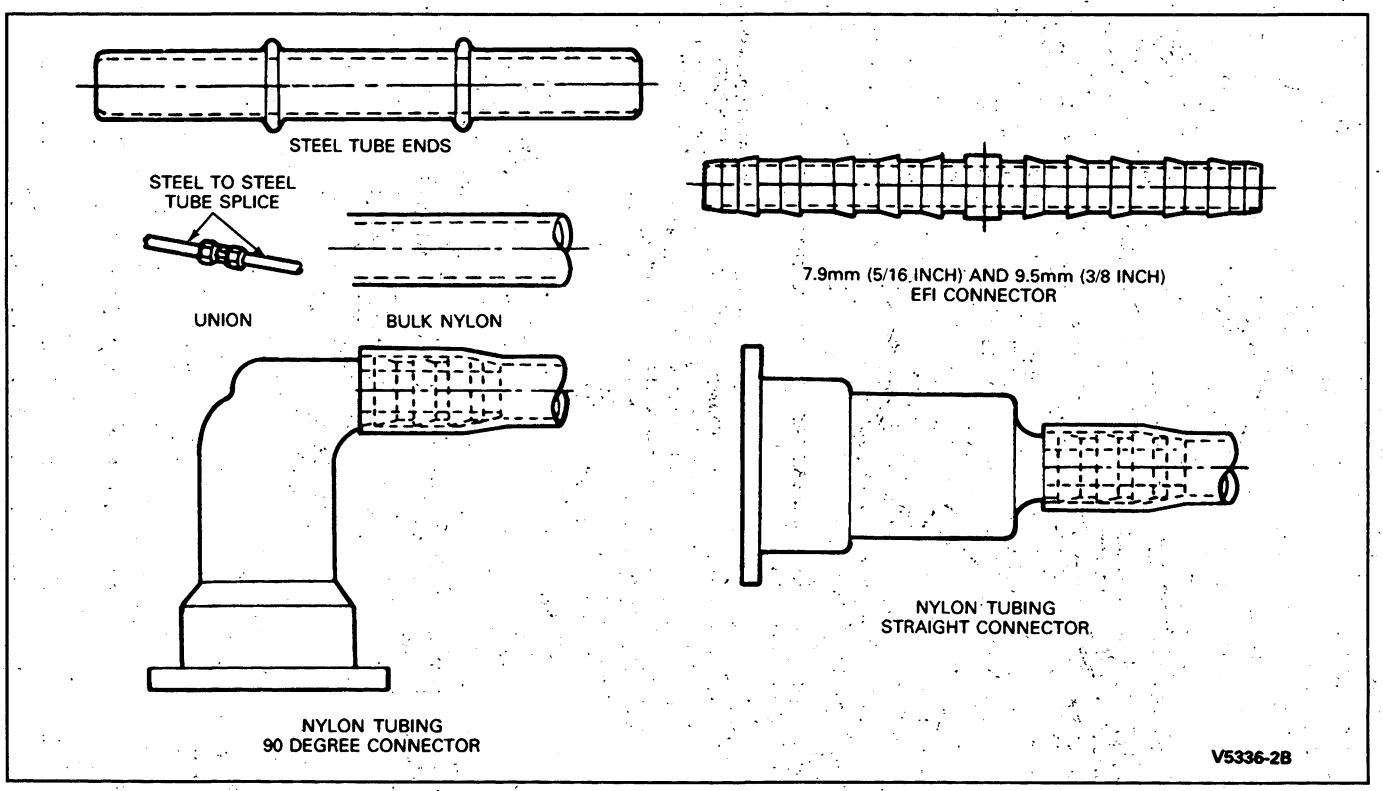


FIG. 27 Fuel Line Service Parts

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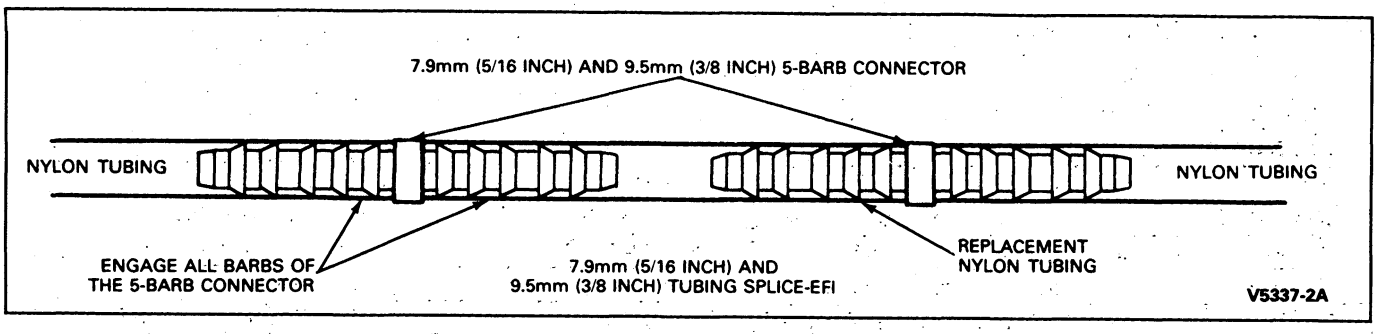


FIG. 28 Splicing Service

SPECIFICATIONS

STANDARD AND AUXILIARY FUEL TANKS — CAPACITY IN LITERS (GALLONS)

Model		Body Style	Location	Advertised Tank Cap. Refill Liters (Gal.)
Series	W. B. MM (In)			
E-350 Cutaway & Stripped Chassis⑤	3505 (138) 4013 (158) 4470 (176)	All	Aft/Axle	136 (36)
E-250, 350, Super Van E-350 Super Wagon	3505 (138)	All	Aft/Axle Midship②	83 (22) 61 (16)
F-250 (4x2)	3378 (133.0)	Reg. Cab	Midship Aft/Axle②	72 (19) 69 (18.2)
	3526 (138.8)	Super Cab	Midship Aft/Axle②	64 (16.5) 69 (18.2)
	3937 (155.0)	Super Cab	Midship Aft/Axle②	72 (19) 69 (18.2)
(4x4)	3378 (133.0) w/o E 4OD	Reg. Cab/ Cab Chassis	Midship① Aft/Axle①②	72 (19) 69 (18.2)
	3937 (155.0)	Super Cab	Midship① Aft/Axle①②	72 (19) 69 (18.2)
F-350 (4x2) and (4x4)	3378(133.0)⑥	Reg. Cab/ Cab Chassis	Midship Aft/Axle②	72 (19) 69 (18.2)
F-Super Duty (4x2)	3475 (136.8)	Cab Chassis/ FSD	Midship Aft/Axle③④	72 (19) 72 (19)
	4084 (160.8)	Cab Chassis/ FSD	Midship Aft/Axle③④	72 (19) 72 (19)
	3937 (155.0)	Crew Cab	Midship Aft/Axle②	72 (19) 72 (19)
F-250-350 (4x4)	3378 (133.0)	Reg. Cab/ Cab Chassis	Midship⑦ Aft/Axle	87 (23.0) 69 (18.2)
F-Super Duty Commercial Stripped Chassis	4013 (158.0)	Stripped Chassis	Aft/Axle	151 (40)

① W/R.P.O. Skid Plate
② Steel Auxiliary Tank
③ Plastic Auxiliary
④ Standard Skid Plate
⑤ 15 Liters (4 Gal.) Throwaway Standard on RV Chassis/RV Cutaway, Commercial Cutaway and Commercial Chassis.
⑥ (4x4) W/O E 4OD and All (4x2)
⑦ Plastic Tank

CV4267-2F

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SPECIAL SERVICE TOOLS

SPECIAL SERVICE TOOLS

Tool	Description
T63P-9171-A	Keystone Clamp Pliers
T74P-9275-A	Fuel Tank Sender Wrench
D87L-9280-A	Spring-Lock Coupling Tool - 3/8 inch
D87L-9280-B	Spring-Lock Coupling Tool - 1/2 inch
T83P-19623-C	Spring Lock Coupling Tool - 5/8 in.

CV5936-1A

ROTUNDA EQUIPMENT

Tool	Description
014-00702	Vacuum/Pressure Tester
034-00002	Fuel Storage Tanker
034-00006	Suction Pump
134-00001	Plastic Fuel Line Connector Tool

CV5937-1A

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SECTION 25-51 Fuel Filters—Diesel Engines

SUBJECT	PAGE
DESCRIPTION	25-51-1
REMOVAL AND INSTALLATION	
Fuel Filter	25-51-1
VEHICLE APPLICATION	25-51-1

VEHICLE APPLICATION

All Models with 7.3L Diesel Engine.

DESCRIPTION

Refer to the Owner's Guide Supplement for fuel filter information. The fuel filter used on the 7.3L diesel is shown in Fig. 1.

REMOVAL AND INSTALLATION

Refer to Figs. 1 through 4.

Fuel Filter

Removal

1. Disconnect battery ground cables from both batteries.
2. Place a container under vehicle and drain fuel from fuel filter.
3. Remove water drain tube from bottom of filter assembly.
4. Unscrew water separator drain bowl and remove.
5. Unscrew fuel filter element and discard.

Installation

1. Clean gasket surfaces of the fuel filter adapter to prevent contamination.
2. Lightly coat filter sealing gaskets with clean diesel fuel.

   NOTE: To avoid fuel contamination, do not add fuel directly to new filter. Allow engine to draw fuel through filter.
3. Screw new filter element onto filter base until seal contacts flange.
4. Tighten filter another 180 to 300 degree turn.

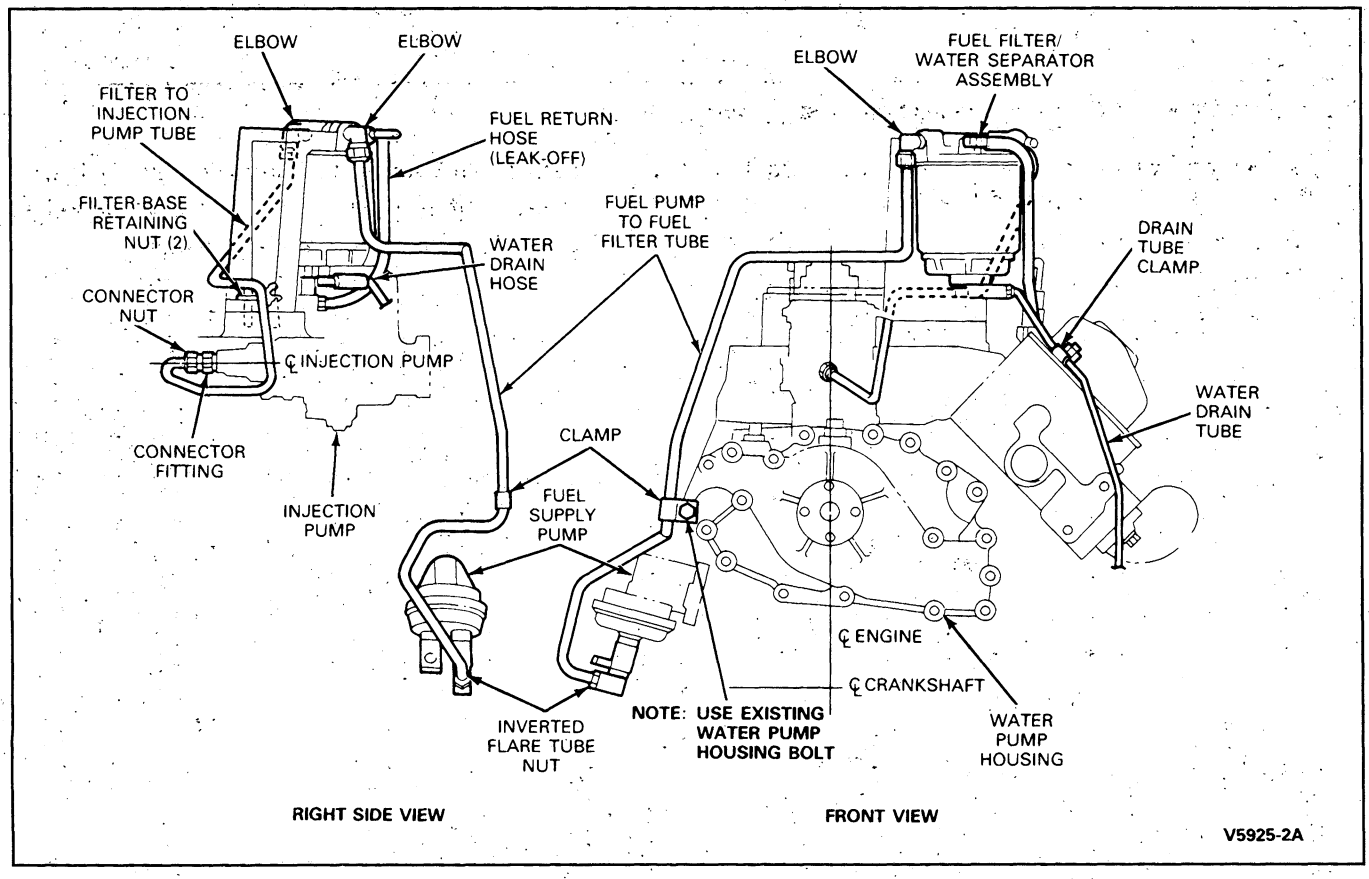


FIG. 1 Fuel Filter Removal and Installation—7.3L Engine—E-Series

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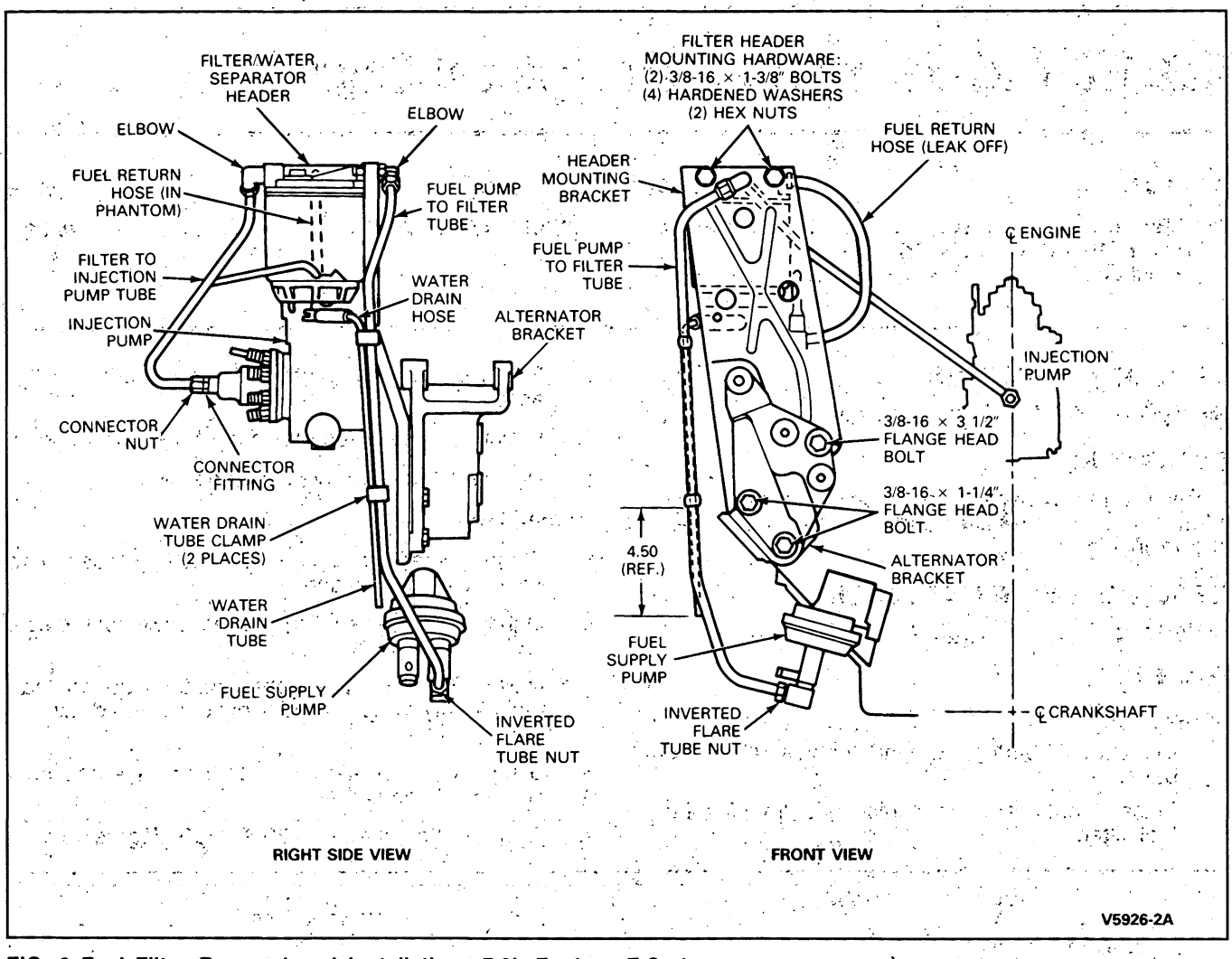


FIG. 2 Fuel Filter Removal and Installation—7.3L Engine—F-Series

5. Screw on water separator drain bowl. Tighten another 180 to 300 degree turn.
6. Install water drain tube.
7. Clean up any spilled fuel from top of engine.
8. Connect battery ground cables to both batteries.
9. Run engine and check for fuel leaks.

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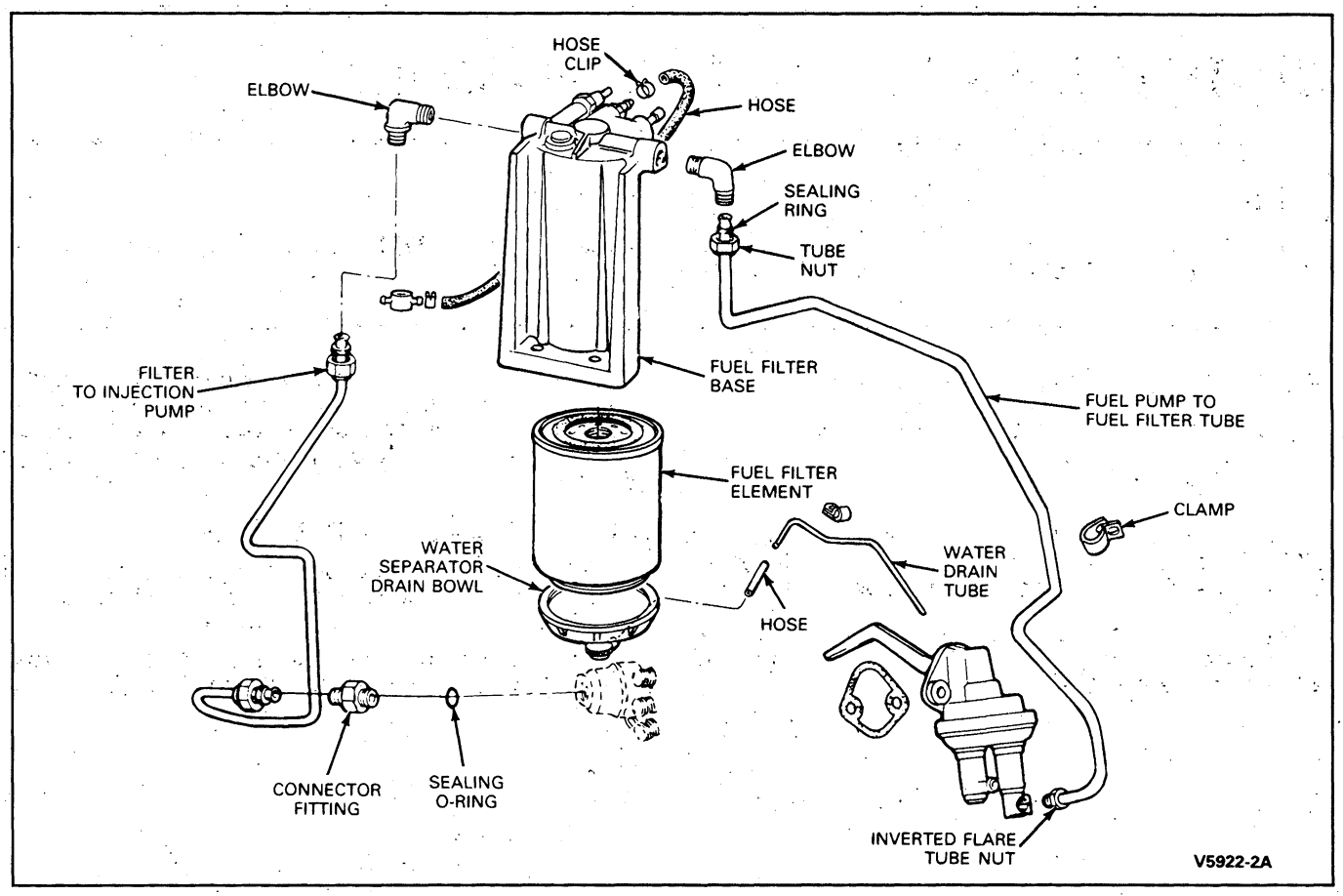


FIG. 3 Fuel Filter/Water Separator and Fuel Supply Pump Assembly—E-Series

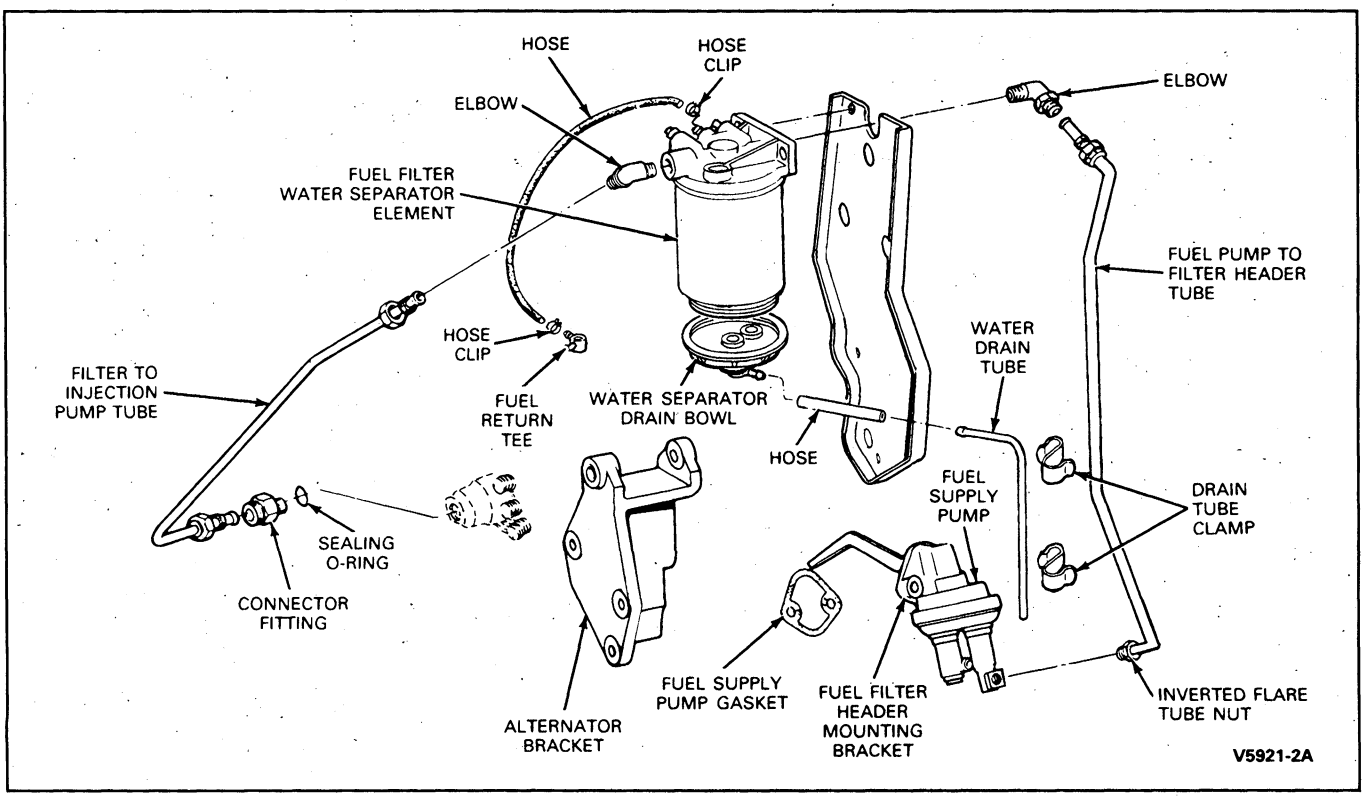


FIG. 4 Fuel Filter/Water Separator and Fuel Supply Pump Assembly—F-Series

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SECTION 25-60 Throttle Linkage—Diesel

SUBJECT	PAGE
ADJUSTMENTS	25-60-1
REMOVAL AND INSTALLATION	25-60-1
VEHICLE APPLICATION	25-60-1

VEHICLE APPLICATION

All vehicles equipped with 7.3L Diesel Engine.

ADJUSTMENTS

Instructions for adjusting throttle linkages used on the 7.3L diesel engine are contained in the following illustrations. Refer to Figs. 1 and 2 for procedures.

Whenever possible, the engine should be at operating temperature when throttle linkage adjustments are made.

Be sure to install throttle return springs in the manner shown on the illustrations. After adjustment, the accelerator should return to idle on slow release of foot pressure, without binding or dragging.

REMOVAL AND INSTALLATION

Linkage disconnect points are shown in the appropriate illustrations. Installation specifications are also given.

Refer to Adjustments for throttle return spring installation and accelerator operation.

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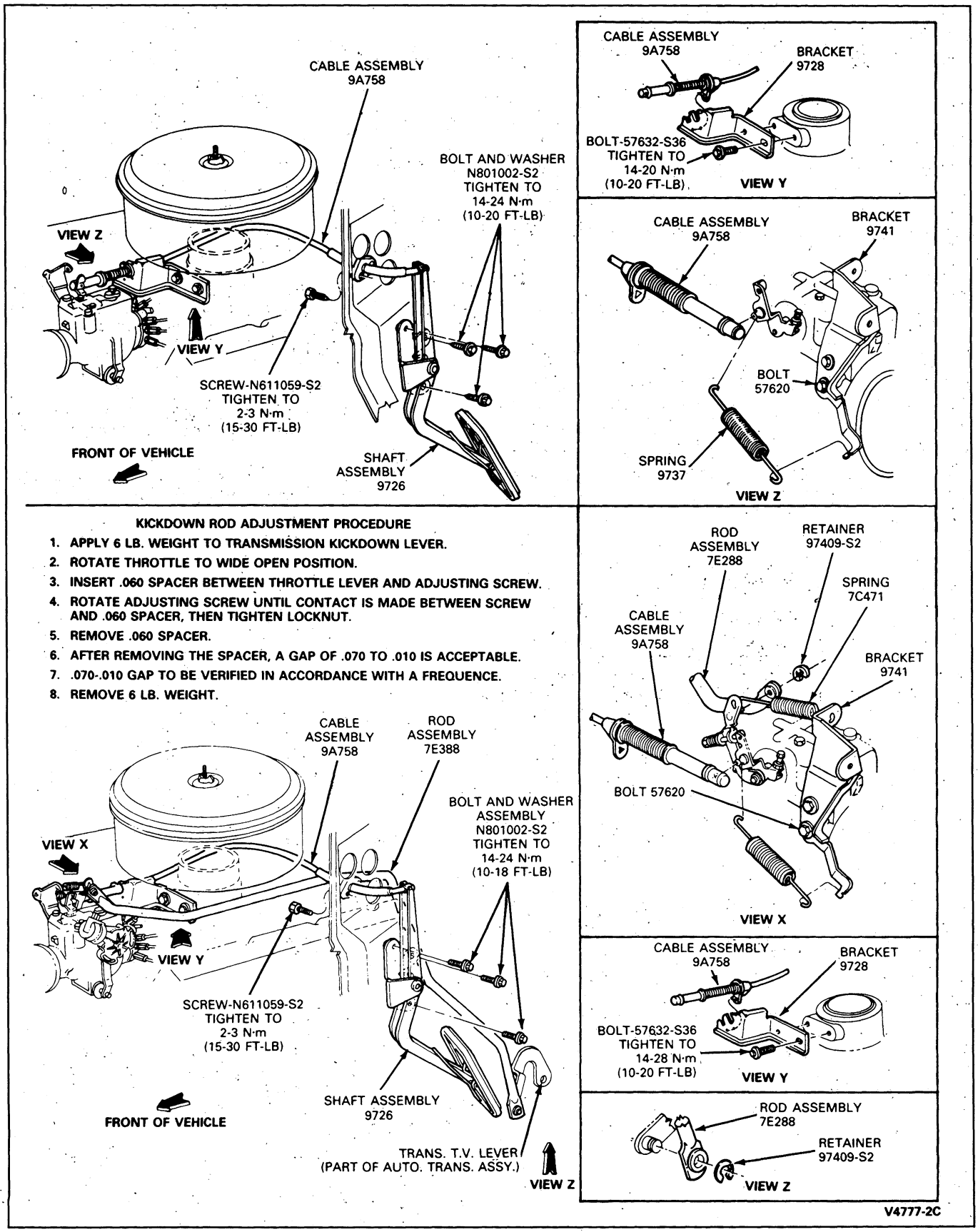


FIG. 1 Throttle Linkage—F-250—F-350—F-Super Duty with 7.3L Diesel Engine

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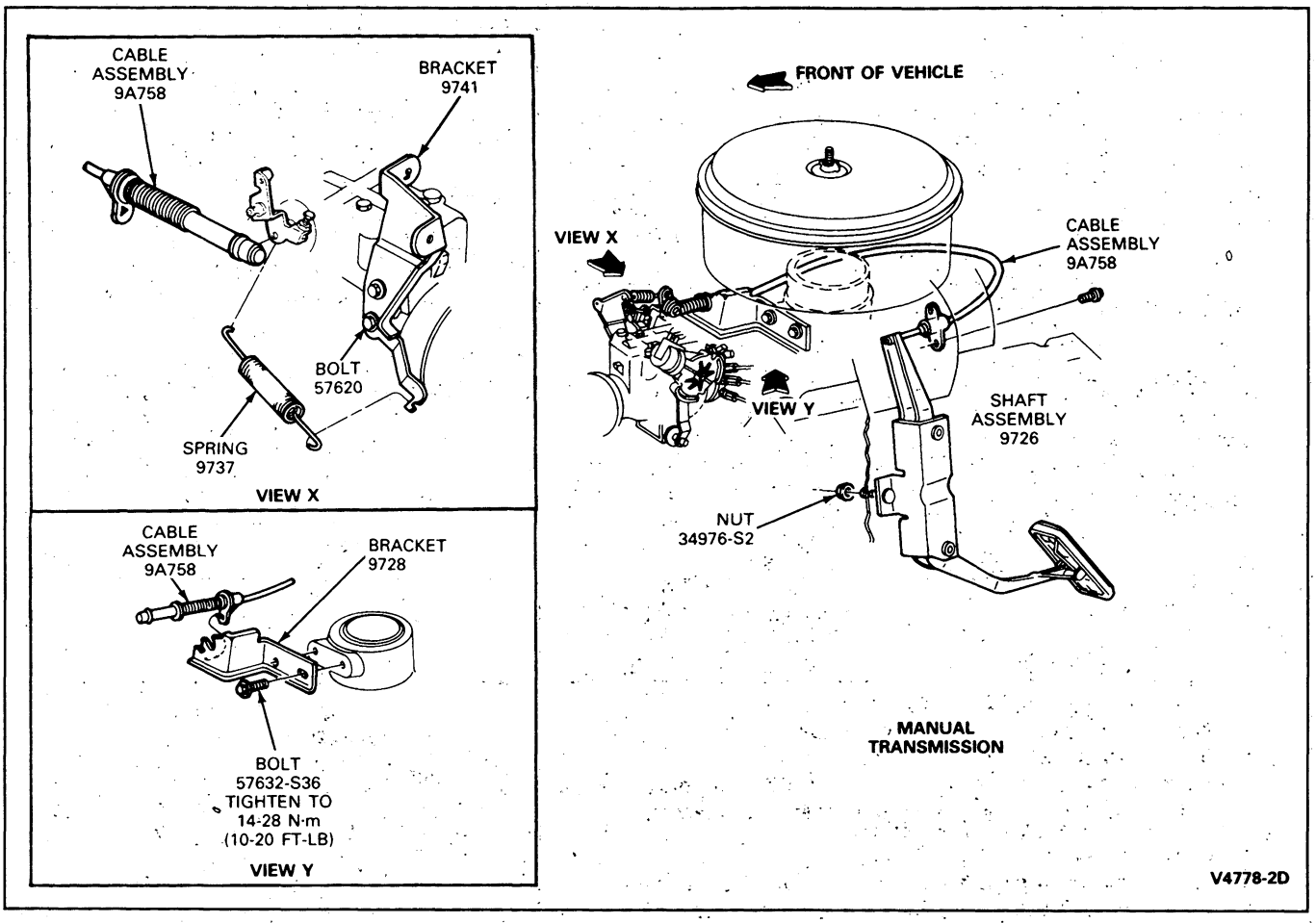


FIG. 2 Throttle Linkage—E-250—E-350 with 7.3L Diesel Engine

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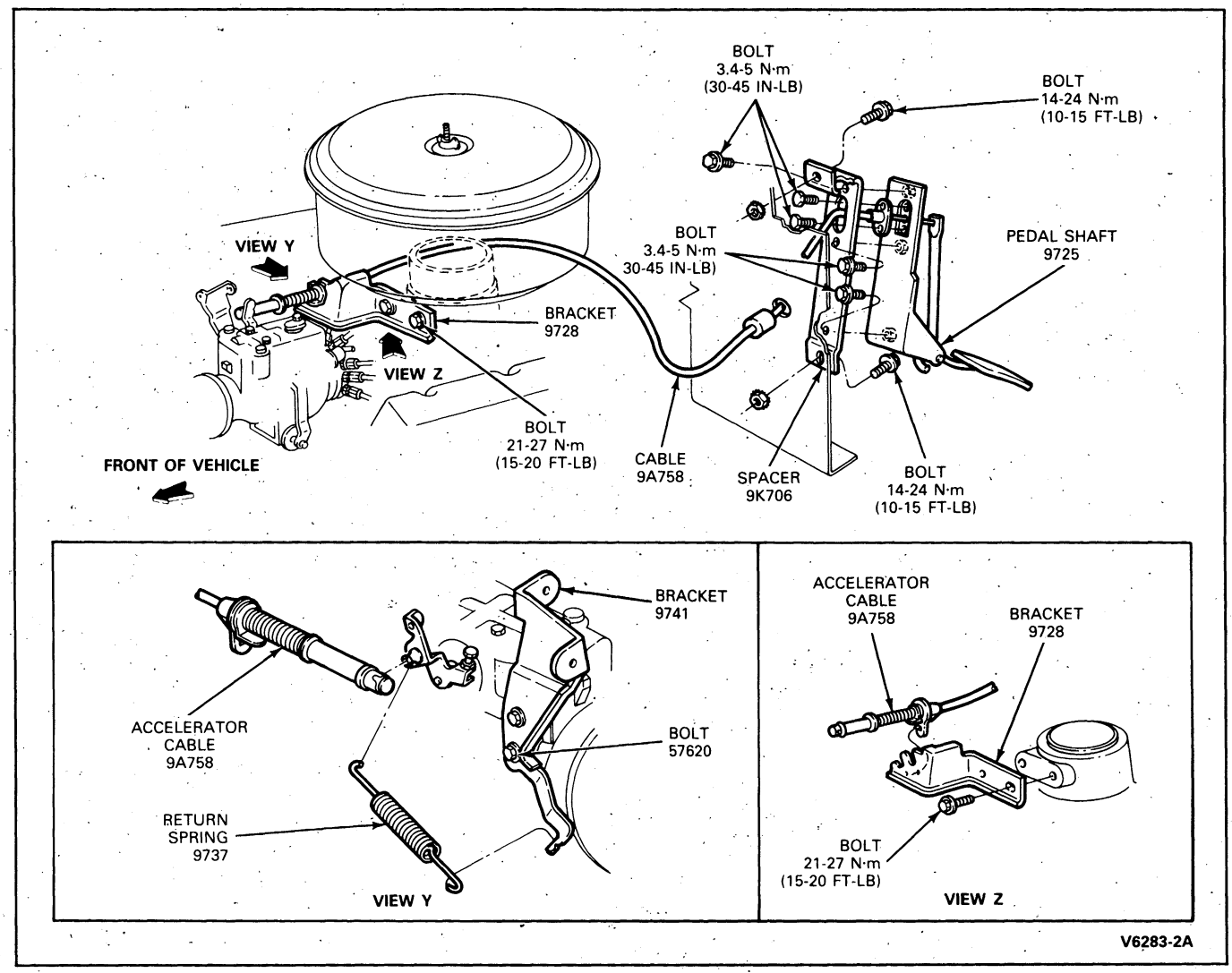


FIG. 3 Throttle Linkage—F-Super Duty Commerical Stripped Chassis Vehicles—7.3L Diesel Engine

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GROUP

EXHAUST SYSTEMS 26

(5000)

SECTION 26-01 General Exhaust System Service

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ADJUSTMENTS	
Exhaust System Alignment	26-01-2
Brush Shield Inspection	26-01-2
DESCRIPTION	26-01-1
DIAGNOSIS AND TESTING	
Diagnosis Guides	26-01-2
Restricted Exhaust System Test-Gasoline Engines	26-01-1
REMOVAL AND INSTALLATION	
Hanger Brackets	26-01-4
Muffler Shields	26-01-4
SPECIAL SERVICE TOOLS	26-01-21
SPECIFICATIONS	26-01-21
VEHICLE APPLICATION	26-01-1

VEHICLE APPLICATION

All Models.

DESCRIPTION

Exhaust systems vary between engine and truck models. Catalytic converters use clamshell catalysts of monolithic construction. The catalytic agent is an alloy of platinum, palladium and rhodium. All gasoline powered vehicles employ the catalytic converter in their emission control systems. All gasoline powered vehicles will run on unleaded fuel.

The diesel engine does not use a catalytic converter, and uses only diesel fuel.

Illustrations given in this Section show typical exhaust systems.

The location and type of exhaust system gaskets, retaining clamps and support brackets are shown in the exhaust system illustrations.

This Section covers general exhaust system alignment procedures and specifications.

DIAGNOSIS AND TESTING

Exhaust system performance complaints such as excessive back-pressure is usually noticeable by its effect on engine performance.

However, other malfunctioning components may have similar effects on engine performance and be characterized by the same symptoms or complaints. It is, therefore, necessary to refer to the engine diagnosis and service procedures in Engine/Emissions Diagnosis* manual, when attempting to diagnose this type of problem.

For general exhaust system complaints refer to the diagnosis guide listed in this Section.

Restricted Exhaust System Test-Gasoline Engines

With the engine at normal operating temperature, connect a Rotunda Vacuum Gauge 059-00008 or equivalent to the intake manifold. A gradual drop in the vacuum gauge reading at idle will indicate a restricted exhaust system.

Refer to the looseleaf Engine/Emission Diagnosis* manual for test procedures for the 7.3L Diesel engine.

ADJUSTMENTS

Inspect inlet pipes, outlet pipes and mufflers for cracked joints, broken welds and corrosion damage that would result in a leaking exhaust system. Inspect the clamps, brackets and insulators for cracks and stripped or badly corroded bolt threads. When pipe clamp(s) are loosened and/or removed to replace a shield, pipe or muffler, replace the clamp(s) if there is reasonable doubt that its service life is limited.

NOTE: Because mufflers are designed without drain holes, it is normal for a certain amount of moisture and staining to be present around the muffler seams. The

*Can be purchased as a separate item.

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Diagnosis Guides

NOISY OR LEAKING EXHAUST DIAGNOSIS GUIDE

TEST STEP		RESULT ▶	ACTION TO TAKE
A0	CLAMPS AND BRACKETS		
• Check for broken or loose clamps and/or brackets.		(OK) ▶	GO to **A1**.
		(OK) ▶	REPAIR or REPLACE as necessary. Restart engine. If noise still exists GO to **A1**.
A1	SYSTEM COMPONENTS		
• Check inlet pipe and muffler for punctures, split seams, or improper welds.		(OK) ▶	GO to **A2**.
		(OK) ▶	REPLACE inlet pipe and/or muffler as necessary. If noise still exists GO to **A2**.
A2	EXHAUST MANIFOLD		
• Inspect exhaust manifold for loose fasteners or cracks.		(OK) ▶	GO to **B0**.
		(OK) ▶	TIGHTEN fasteners to specification or REPLACE exhaust manifold. REFER to specific engine section in this manual.

CU1824-2C

presence of soot, surface rust, or moisture does not indicate a damaged muffler and should not constitute the basis for replacement.

Muffler clamps can be broken due to overtightening during servicing of exhaust leaks. When attempting to eliminate exhaust leaks at joints, the muffler clamp should be tightened to specification limits only. If this does not eliminate the leak, the clamp should be loosened, rotated approximately one-quarter turn, and then retightened to the specification.

The exhaust system, including brush shields, must be free of leaks, binding, grounding and excessive vibrations.

These conditions are usually caused by loose, broken or misaligned clamps, shields, brackets or pipes. If any of these conditions exist, check the exhaust system components and alignment. Align or replace as necessary.

Exhaust System Alignment

Perform the following procedure to align the complete exhaust system:

1. Loosen the pipe connection clamps and the pipe support bracket clamps. Loosen the inlet pipe-to-exhaust manifold attaching nuts.
2. Work from the front and progressively align the exhaust system components and hangers to eliminate any interferences. Make sure that aligning tabs (if used) are fully engaged in their mating slots.
3. Then working from the rear forward, retighten clamps to specifications. Finally, tighten the exhaust manifold to inlet pipe attaching nuts alternately and equally to specifications, so that the pressure on the ball flange will be uniform.

Brush Shield Inspection

Raise the vehicle on a hoist. Brush shields are positioned on the underside of the catalytic converter and the muffler assembly. Shields should be free from random bends which would bring any part of the shield in soft contact with the converter or muffler assembly causing a rattle. The shield should be clear of any combustible matter.

REMOVAL AND INSTALLATION

Refer to Figs. 1 through 10A.

The exhaust system components are removed, disassembled, assembled and installed using standard tools and procedures. Only remove components to the extent necessary to replace worn or damaged components.

Always refer to the Master Parts Catalog for parts usage and interchangeability before replacing a component part of the exhaust system.

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RESTRICTED EXHAUST SYSTEM DIAGNOSIS GUIDE

TEST STEP	RESULT ▶	ACTION TO TAKE
B0 VISUAL INSPECTION		
• Is the exhaust system visually OK?	(OK) ▶	GO to **B1**.
	(OK) ▶	REPLACE any collapsed exhaust components. GO to **B1**.
B1 VACUUM TEST #		
• Attach a Rotunda Vacuum Gauge 059-00008 or equivalent to the intake manifold vacuum source. • Hook-up Rotunda Tachometer 059-00007 or equivalent. • Start engine and gradually increase speed to 2000 RPM with transmission in NEUTRAL. • Is neutral vacuum above 53.8 kPa (16 inches/Hg)?	(OK) ▶	REFER to Engine/ Emission Diagnosis Manual* — Lack of power.
	(OK) ▶	GO to **B2**.
B2 VACUUM TEST — EXHAUST DISCONNECTED #		
• Turn engine off. • Disconnect exhaust system at manifold(s). • Repeat vacuum test. Is the manifold vacuum above 53.8 kPa (16 inches/Hg)?	(OK) ▶	GO to **B3**.
	(OK) ▶	GO to **B4**.
B3 VACUUM TEST — CATALYTIC CONVERTER(S) ON/ MUFFLER(S) OFF #		
• Turn engine off. • Reconnect exhaust system at exhaust manifold(s). • Disconnect muffler(s). • Repeat vacuum test. Is the manifold vacuum above 53.8 kPa (16 inches/Hg)?	(OK) ▶	REPLACE muffler and RETEST.
	(OK) ▶	REPLACE catalytic converter and inspect muffler to be sure converter debris has not entered muffler.
B4 EXHAUST MANIFOLD RESTRICTED		
• Remove the exhaust manifold(s). Inspect the ports for casting flash by dropping a length of chain into each port. Do not use a wire or light to check ports. The restriction may be large enough for them to pass through but small enough to cause excessive back pressure at high engine RPM.	(OK) ▶	REFER to Engine/ Emission Diagnosis Manual* — Lack of Power.
	(OK) ▶	REMOVE casting flash. If flash cannot be removed, REPLACE exhaust manifold(s) and RETEST.

* Can be purchased as a separate item.
Gasoline engine only.

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Muffler and Outlet Pipe Assembly

Removal

1. Remove muffler and outlet pipe assembly clamp and U-bolt assemblies as required to remove worn or damaged components (Figs. 1 through 10A).
2. Disconnect muffler and outlet pipe assembly bracket and insulator assemblies.
3. Remove muffler and outlet pipe assembly. It may be necessary to heat the muffler/converter joint in order to separate the muffler assembly from the converter.
4. On Super Cab and Crew Cab models, remove extension pipe.
5. If so equipped, disconnect catalytic converter bracket and insulator assembly.

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NOTE: For rod and insulator type hangers, apply a soap solution to the insulator surface and rod ends to permit easier removal of the insulator from the rod end. Avoid use of oils or silicone since they do not dry and may allow the insulator to slip back off once it is installed.

6. Remove catalytic converter.
7. On models with Managed Thermactor Air (M.T.A.), disconnect M.T.A. tube assembly.
8. Disconnect inlet pipe from exhaust manifold.
9. Remove inlet pipe assembly.

Installation

CAUTION: Ensure positioning tabs and slots provided at the converter/muffler assembly connections are properly aligned to avoid ground out conditions with chassis components during assembly.

1. On models with catalytic converter, position and install heat shields.
2. Place muffler and outlet pipe assembly in vehicle by sliding in over axle housing.
3. Position muffler and outlet pipe assembly by inserting it over the end of the converter and aligning slot to converter tab.
4. Apply a soap solution to metal support rods on muffler and outlet pipe assembly.

   NOTE: Avoid use of oils or silicone since they do not dry and may allow the insulator to slip back off once it is installed.
5. Force metal support rods through rubber insulators.
6. Attach hanger bracket clamps and U-bolts and tighten to specifications shown on illustration (Figs. 1 through 10A).
7. Install and tighten the sealing clamp at muffler to converter joint.

CAUTION: To ensure a correctly sealed joint, the correct clamp must be used. Figs. 1 through 10A.

Hanger Brackets

Removal

1. Remove muffler and outlet pipe assembly from brackets.
2. Remove nuts from bracket and remove from frame.
3. For F-Series rear hanger bracket remove rivet which holds bracket to frame.

Installation

1. Position bracket to frame, install and tighten nuts.
2. For F-Series rear hanger bracket, position bracket on frame and attach with M10-1.5 nut and bolt. Tighten to 68-94 N·m (50-70 ft-lb).

Muffler Shields

Shields are attached in one of two ways: a single band clamp and two screws at the rear of the muffler or two band clamps.

Removal

1. Remove band strap(s) from clamp worm gear(s).
2. Remove two screws and washer assemblies which hold shield to rear of muffler.

Installation

1. Position shield(s) on muffler body.
2. Install two screws to rear of muffler. Tighten screws and washer assemblies to 16-23 N·m (12-17 ft-lb).
3. Start band strap(s) in worm gear(s). Tighten to 1.8-2.3 N·m (16-20 in-lb).

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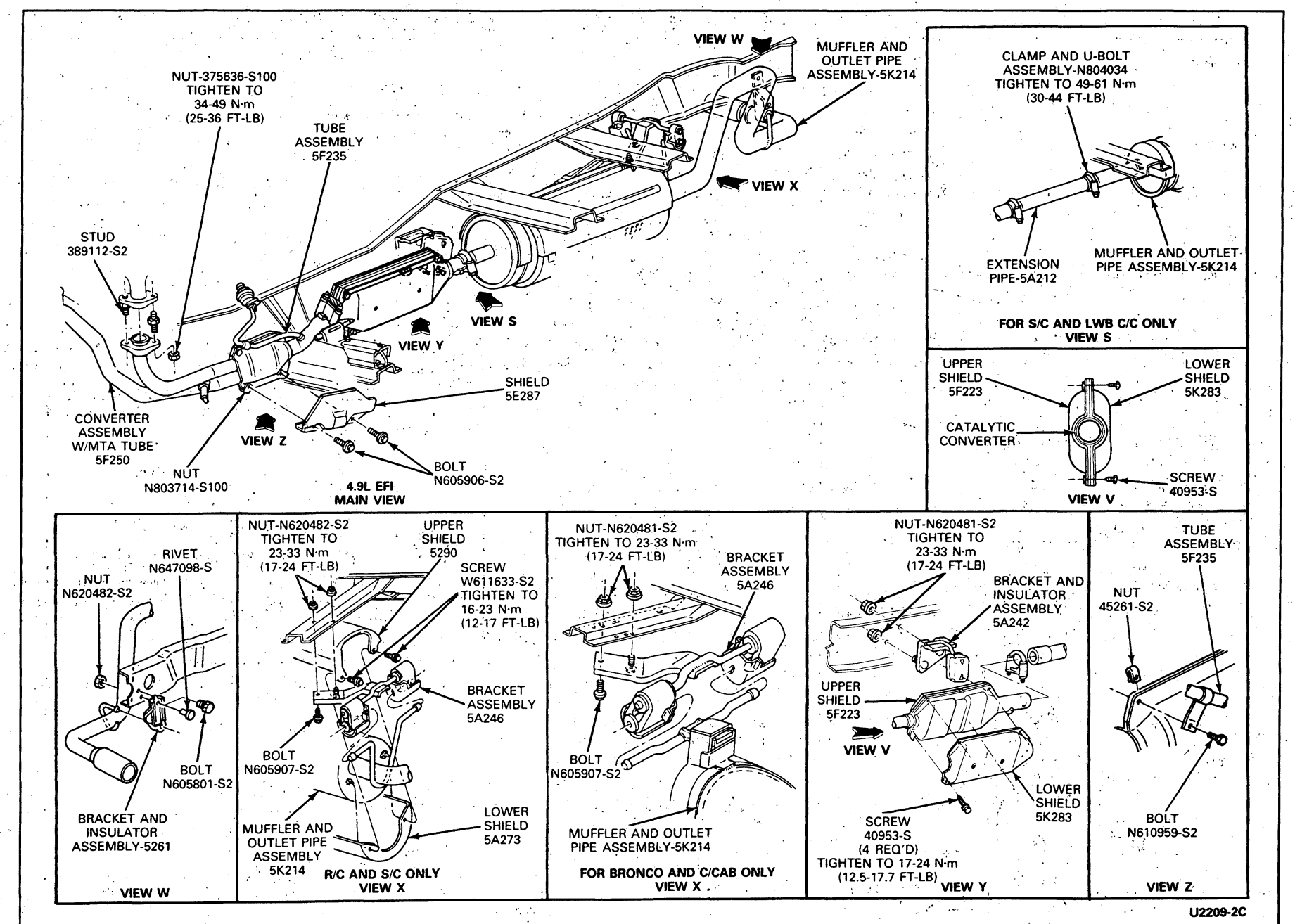


FIG. 1 Bronco, F-150—F-350 Regular Cab, Super Cab and Chassis Cab, 4x2 and 4x4, 4.9L EFI Engine Exhaust System

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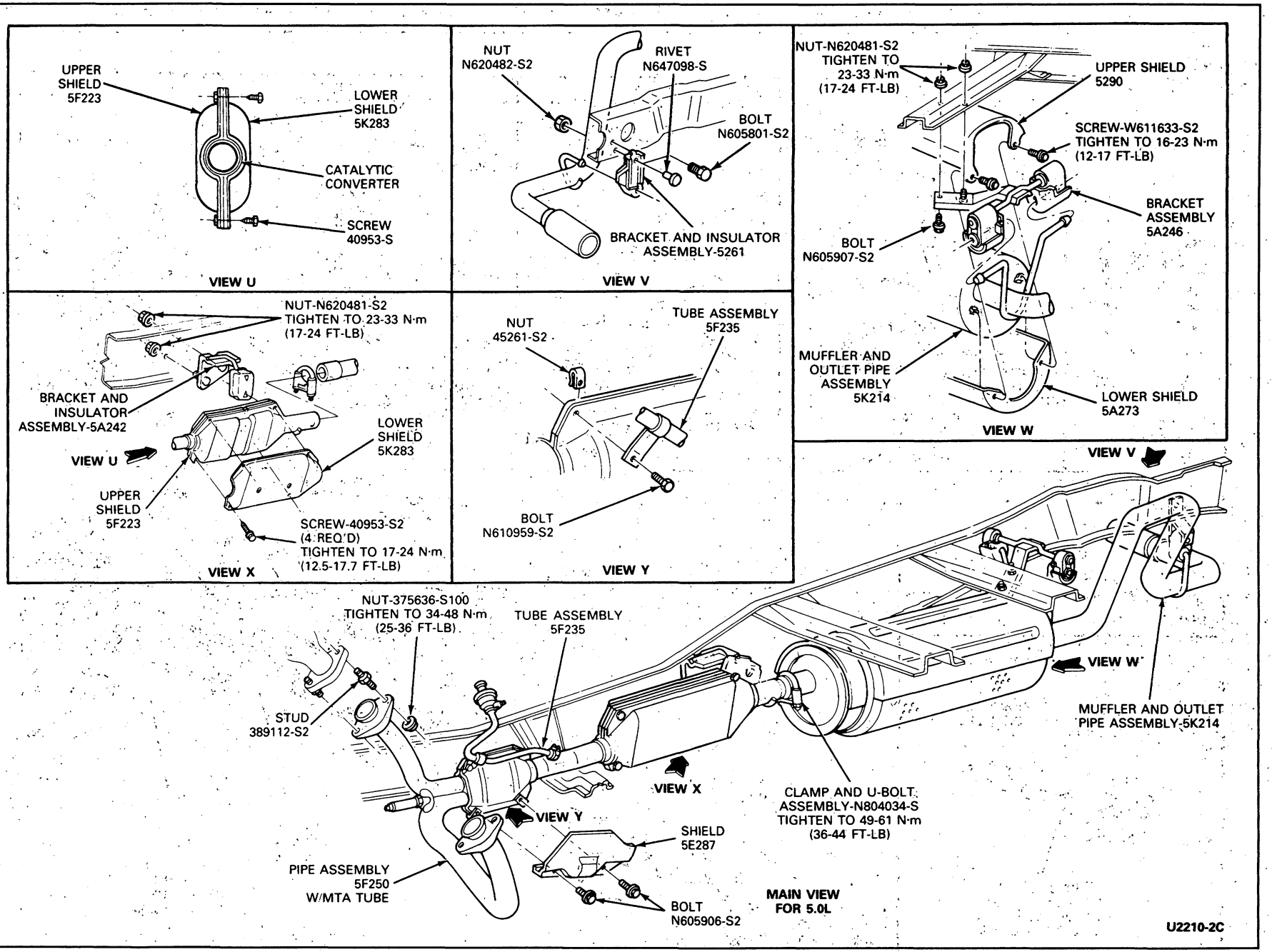


FIG. 2 Bronco, F-150—F-350 Regular Cab and Super Cab, 4x2 and 4x4, 5.0L EFI Engine Exhaust System

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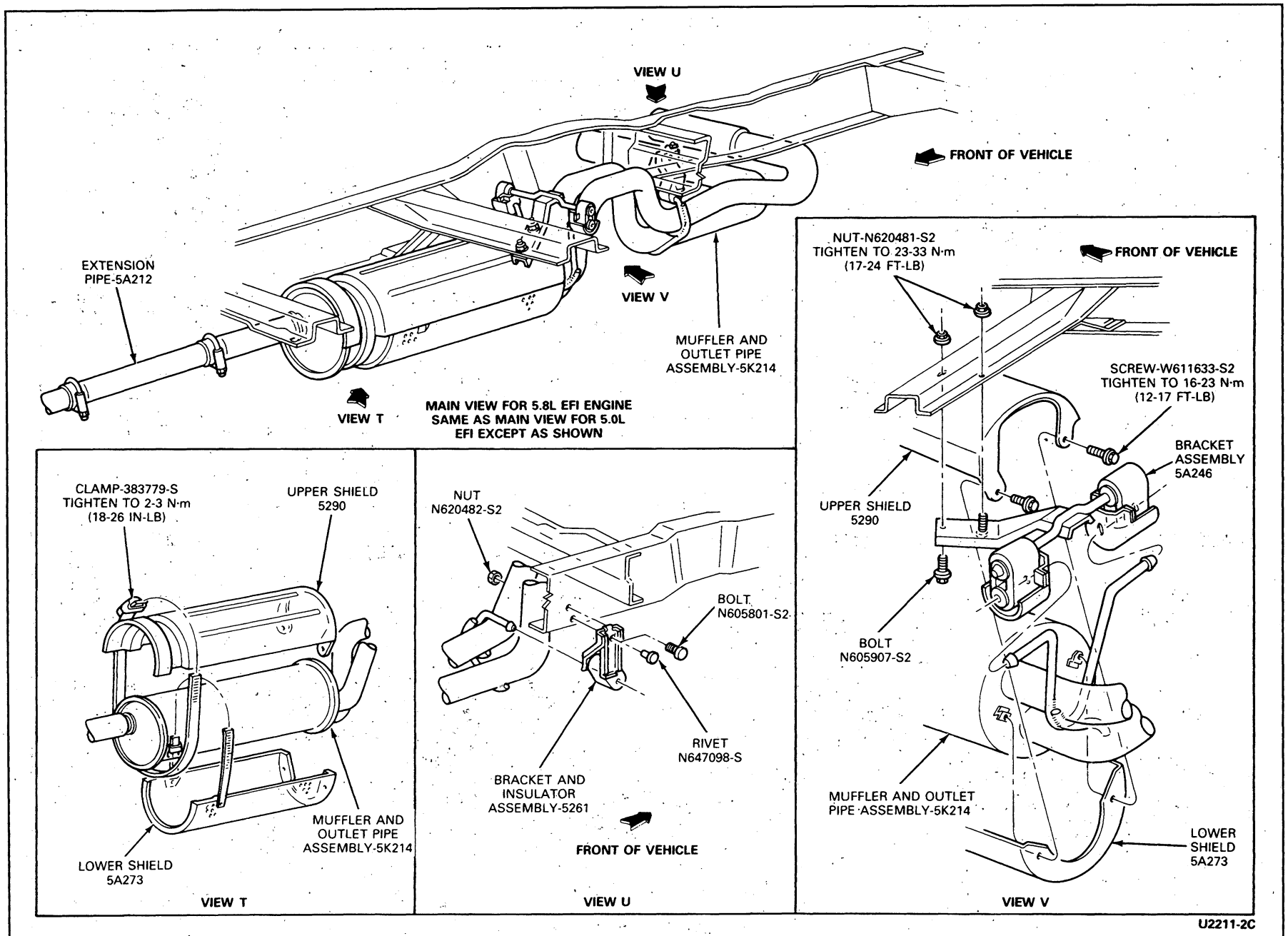


FIG. 3 Bronco, F-150—F-350 Regular Cab and Super Cab, 4x2 and 4x4, 5.8L EFI Engine Exhaust System—Under 8500 GVW

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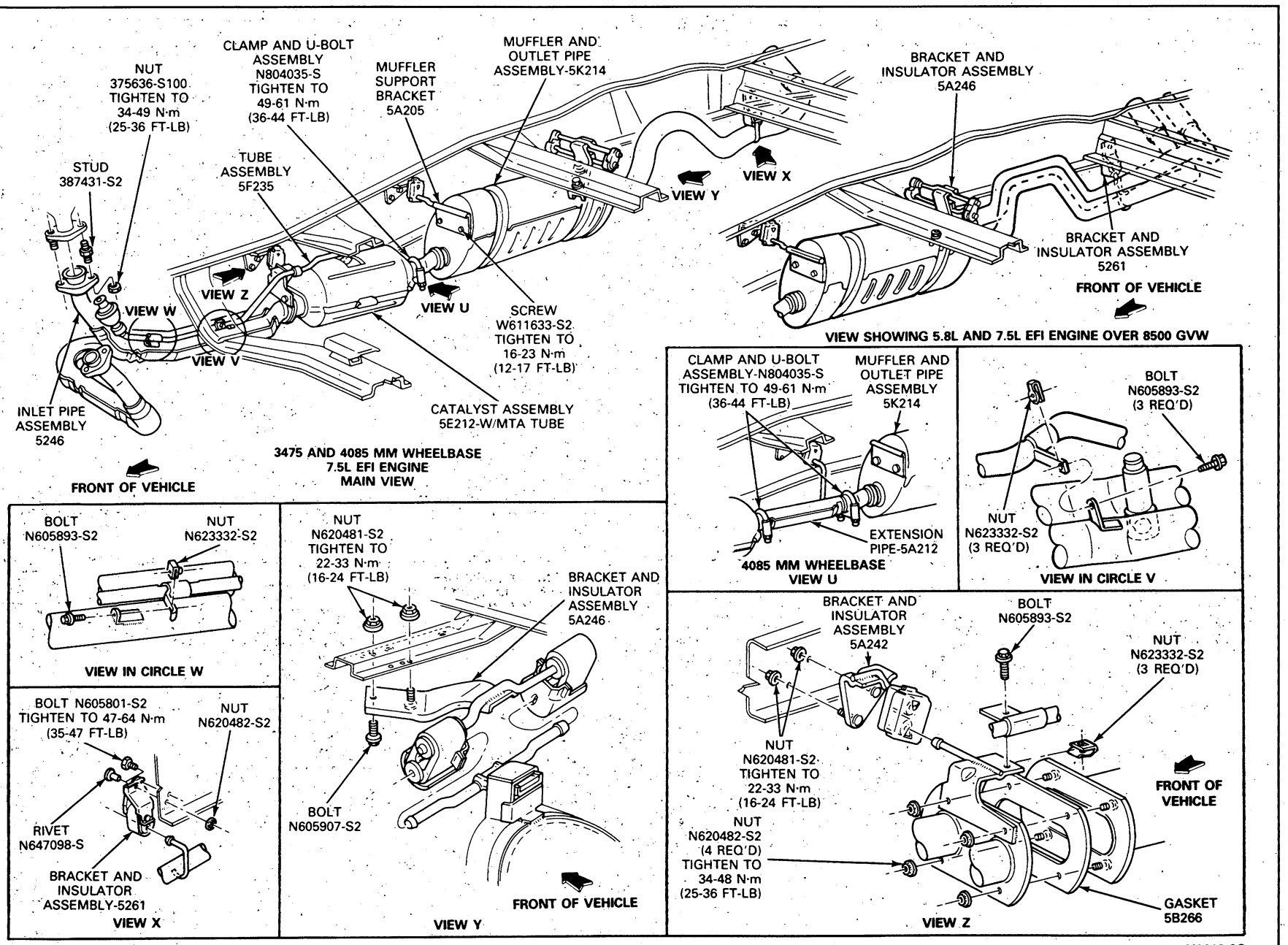


FIG. 4 F-250—F-350—F-Super Duty Regular Cab, Super Cab and Chassis Cab, 4x2 and 4x4, 5.8L EFI and 7.5L EFI Engine Exhaust Systems—Over 8500 GVW

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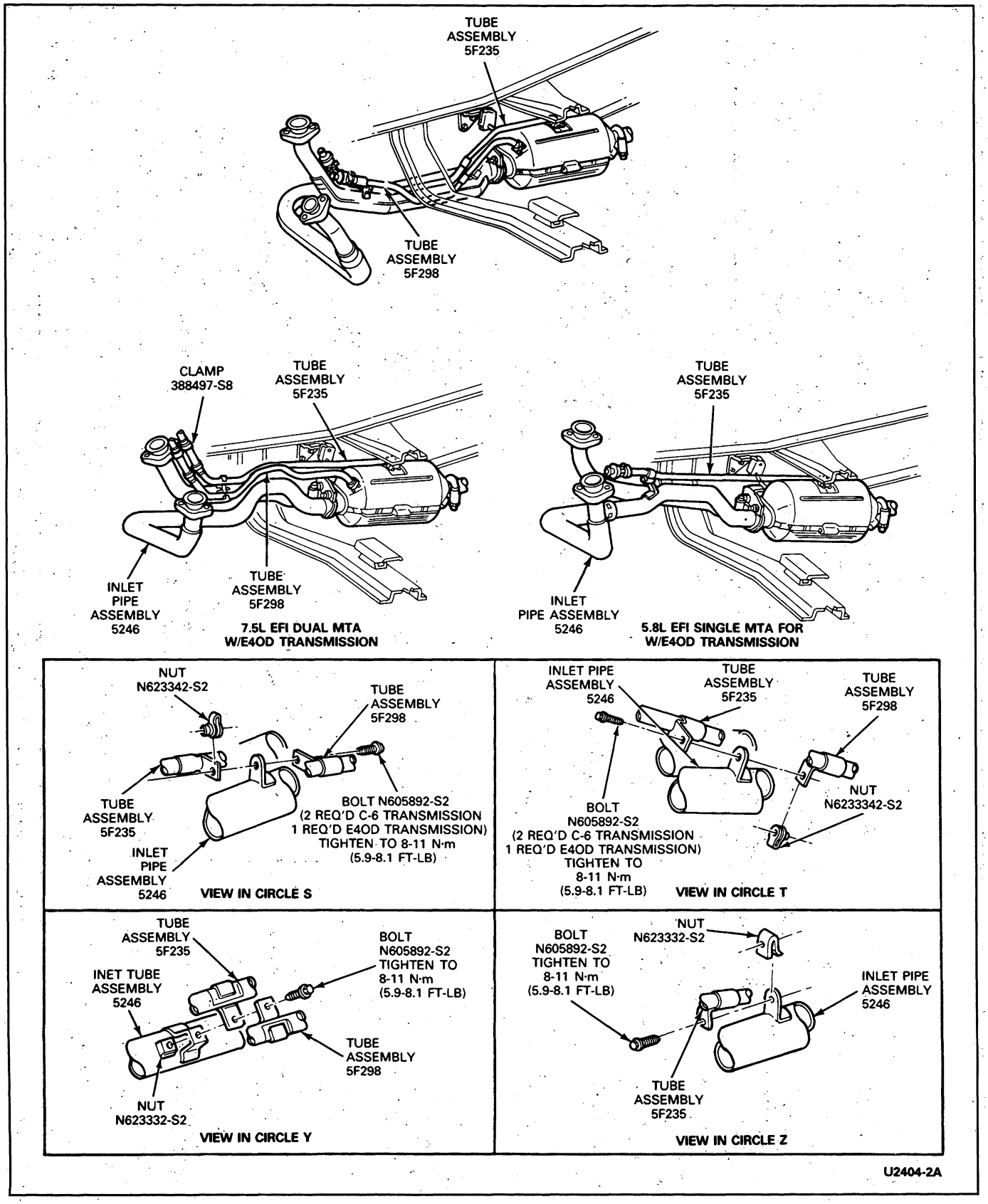


FIG. 4A F-250—F-350—F-Super Duty Regular Cab, Super Cab and Chassis Cab, 4x2 and 4x4, 5.8L EFI and 7.5L EFI Engine Exhaust System—Over 8500 GVW (Cont'd)

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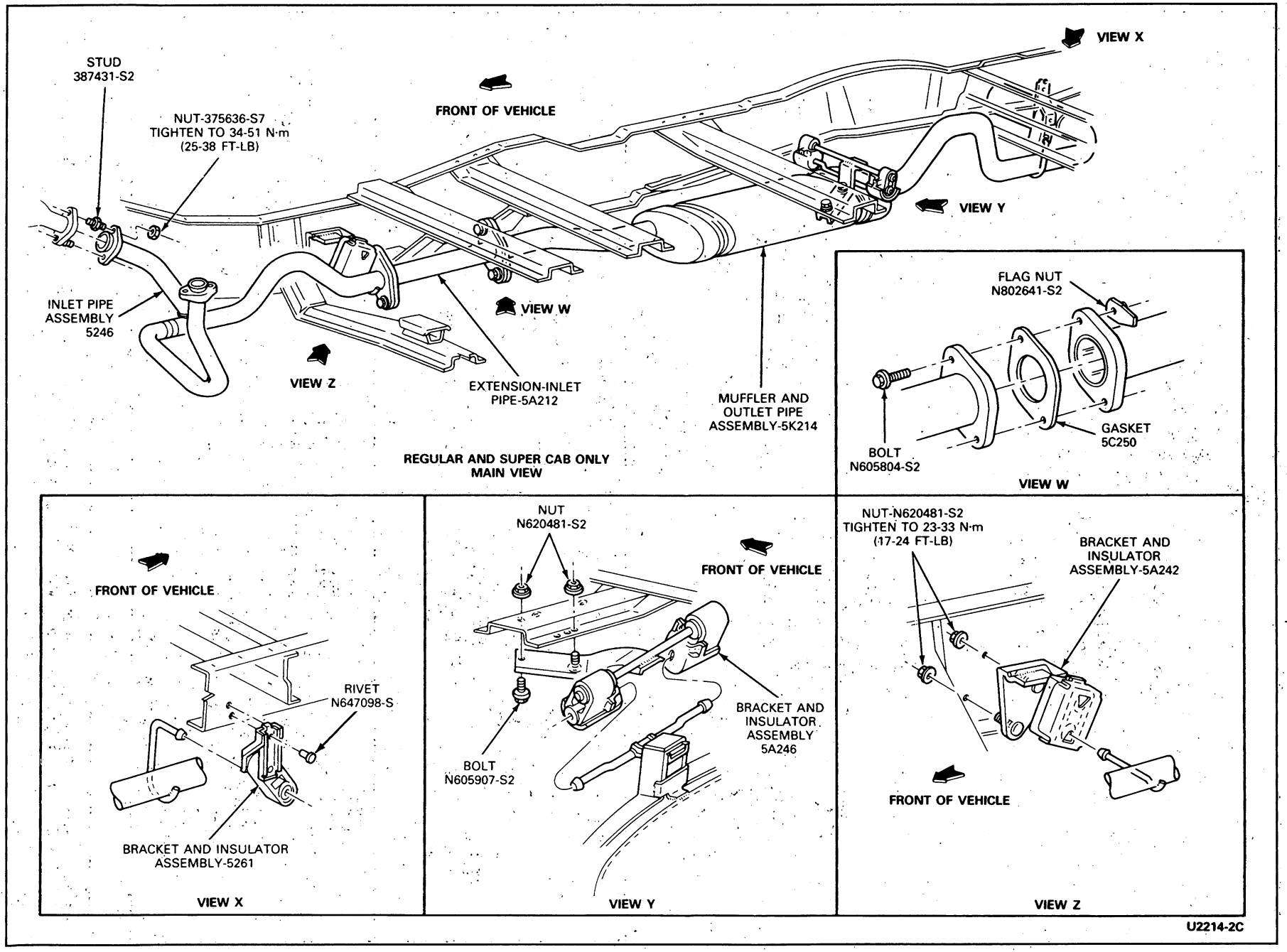


FIG. 5 F-250—F-350 Regular Cab, Super Cab and Chassis Cab—7.3L Diesel Engine Exhaust System

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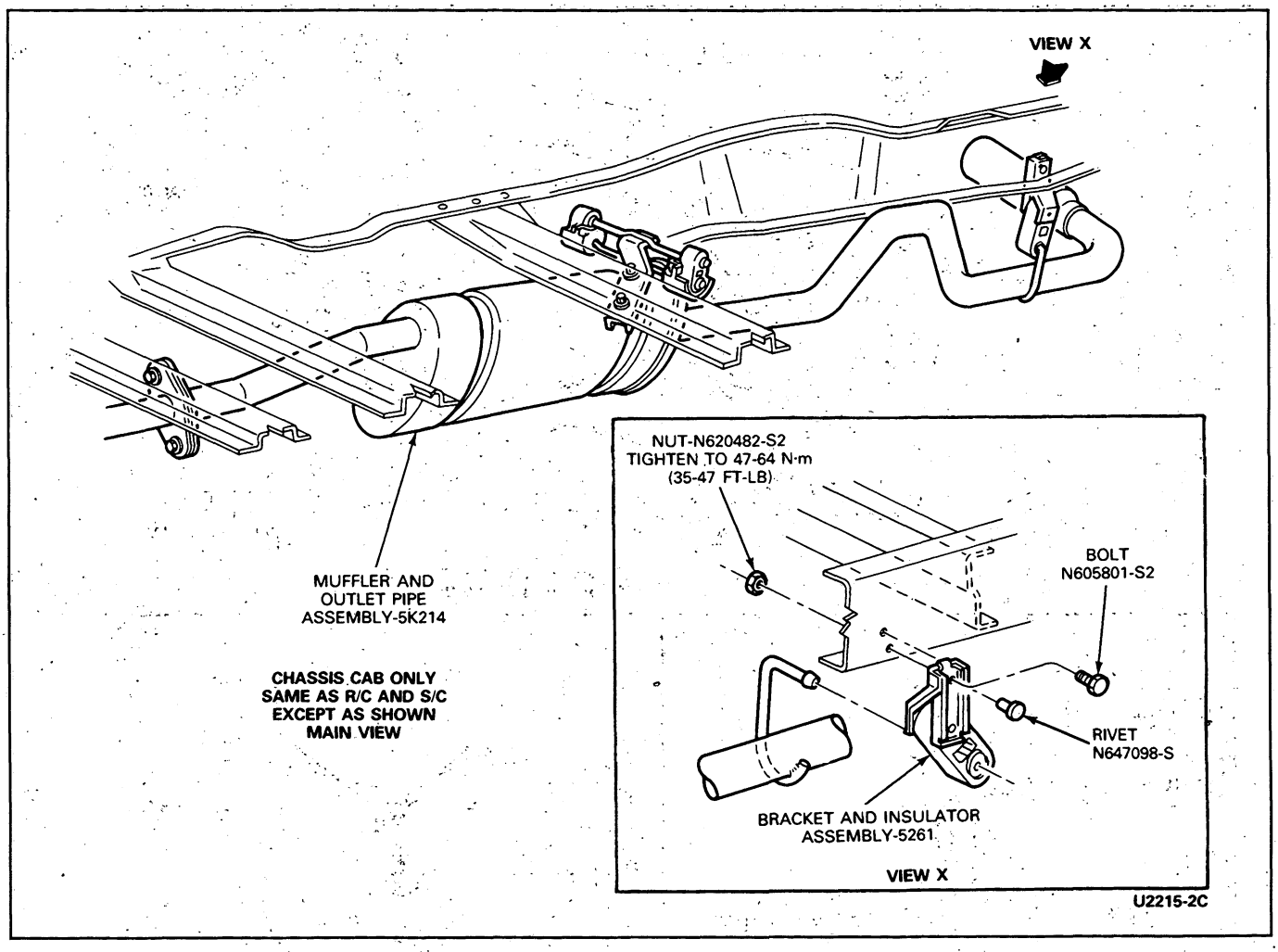


FIG. 5A F-250 H.D., F-250—F-350 Regular Cab, Super Cab and Chassis Cab—7.3L Diesel Engine Exhaust System (Cont'd)

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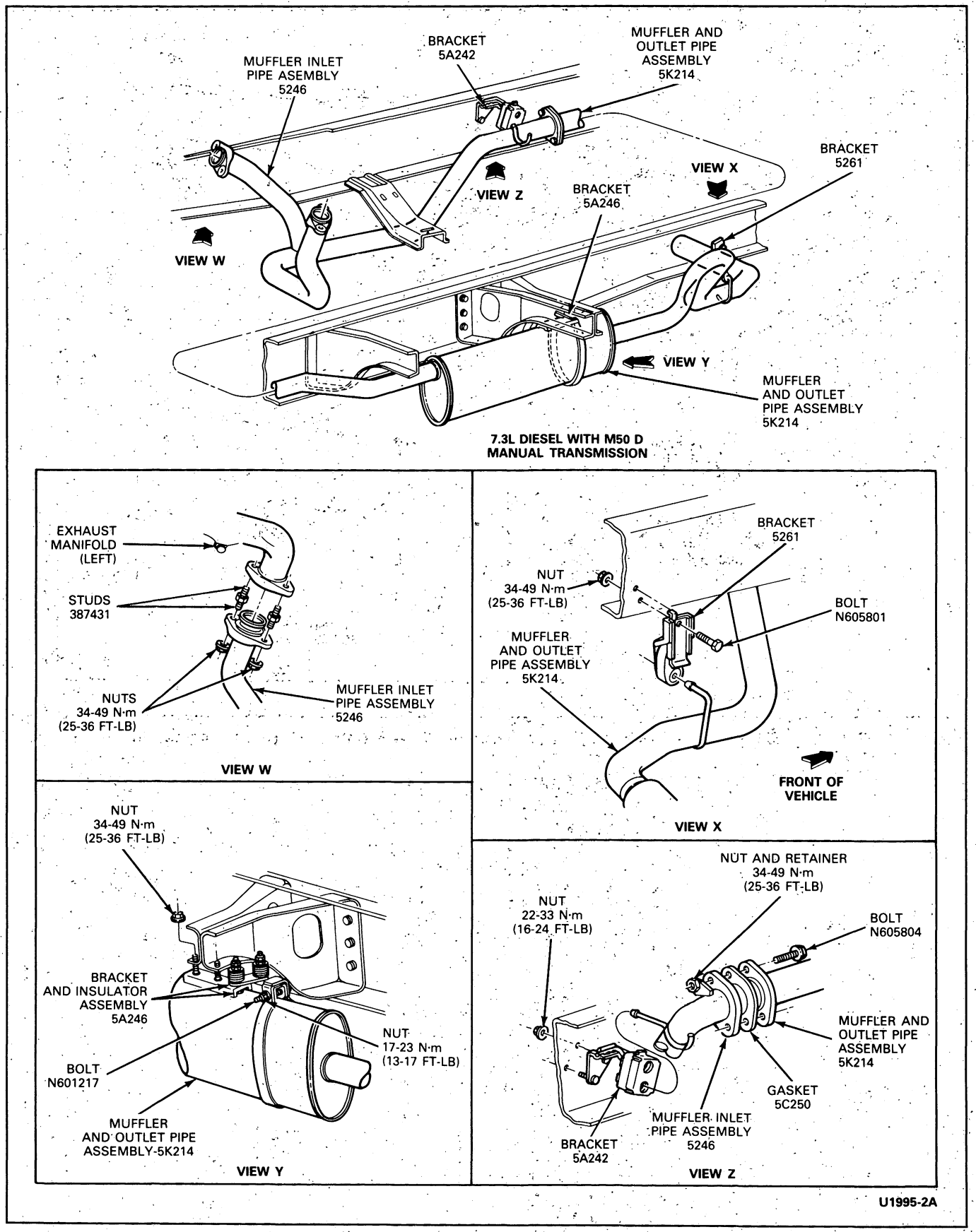


FIG. 6 F-Super Duty Commercial Stripped Chassis Vehicles—7.3L Diesel

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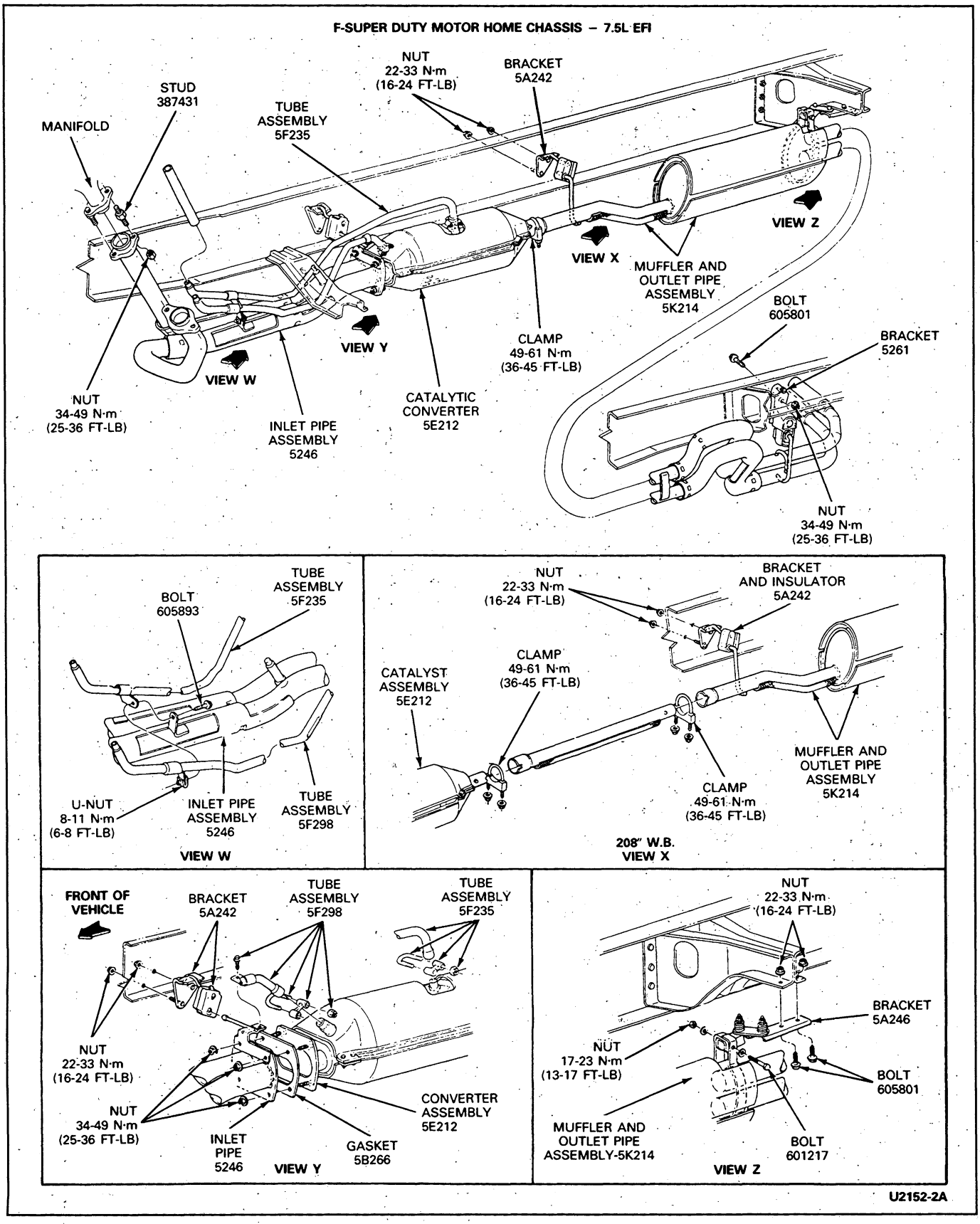


FIG. 7 F-Super Duty Motor Home Chassis Vehicles—7.5L EFI

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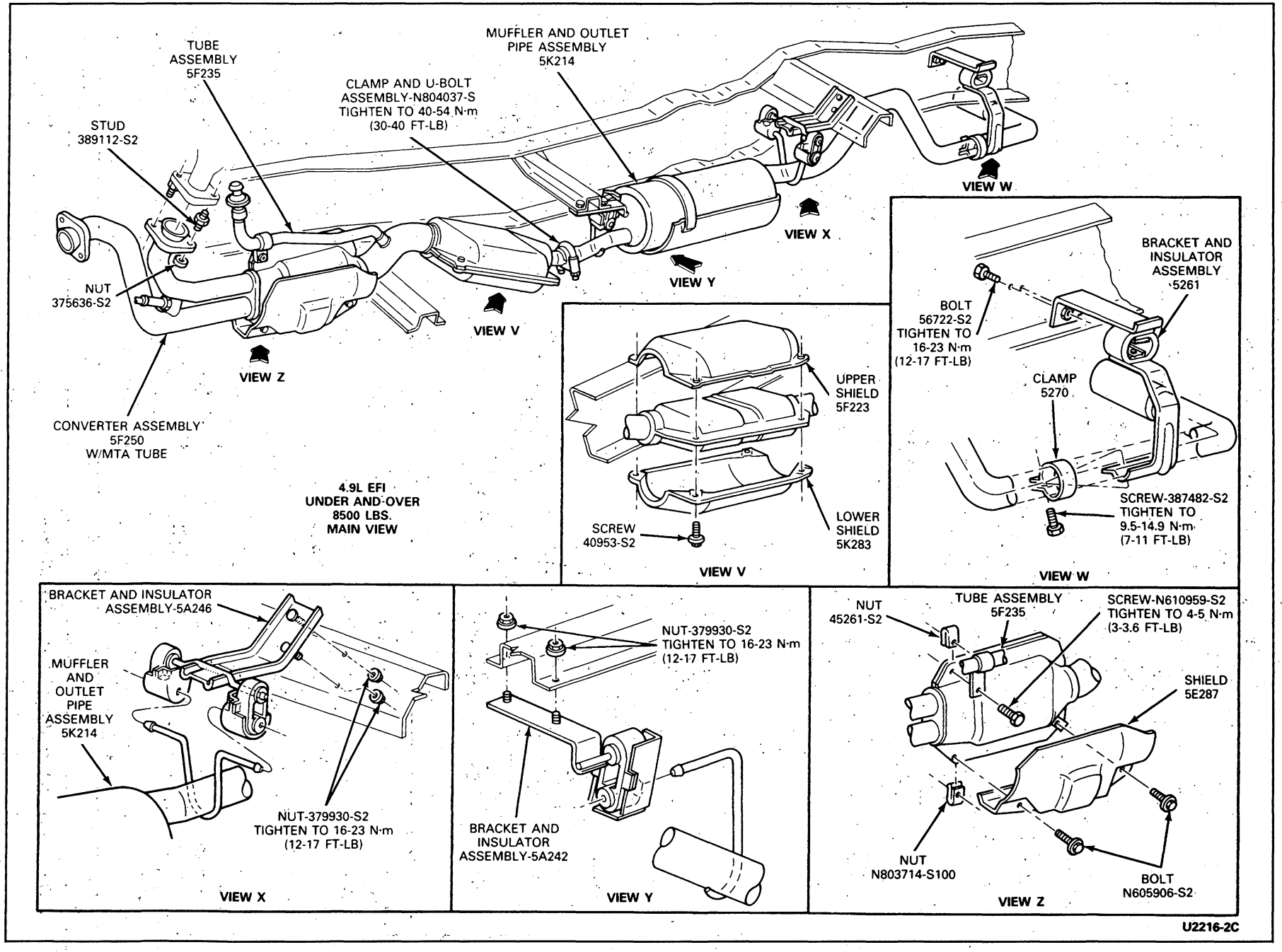


FIG. 8 E-150—E-350 4.9L (300 CID) EFI, 5.0L (302 CID) EFI and 5.8L (352 CID) EFI Engine Exhaust Systems

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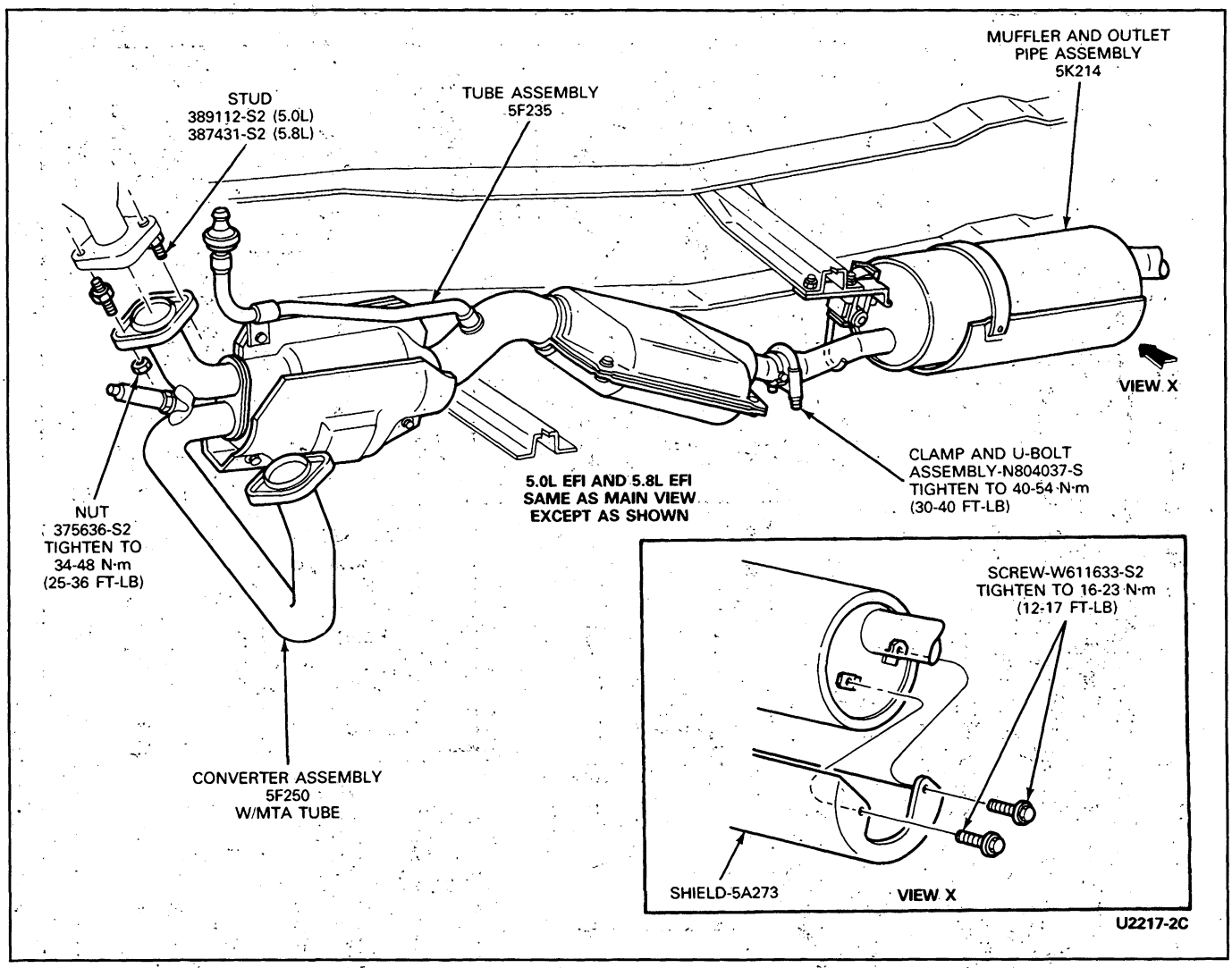


FIG. 8A E-150—E-350 4.9L (300 CID) EFI, 5.0L (302 CID) EFI and 5.8L (352 CID) EFI Engine Exhaust Systems (Cont'd)

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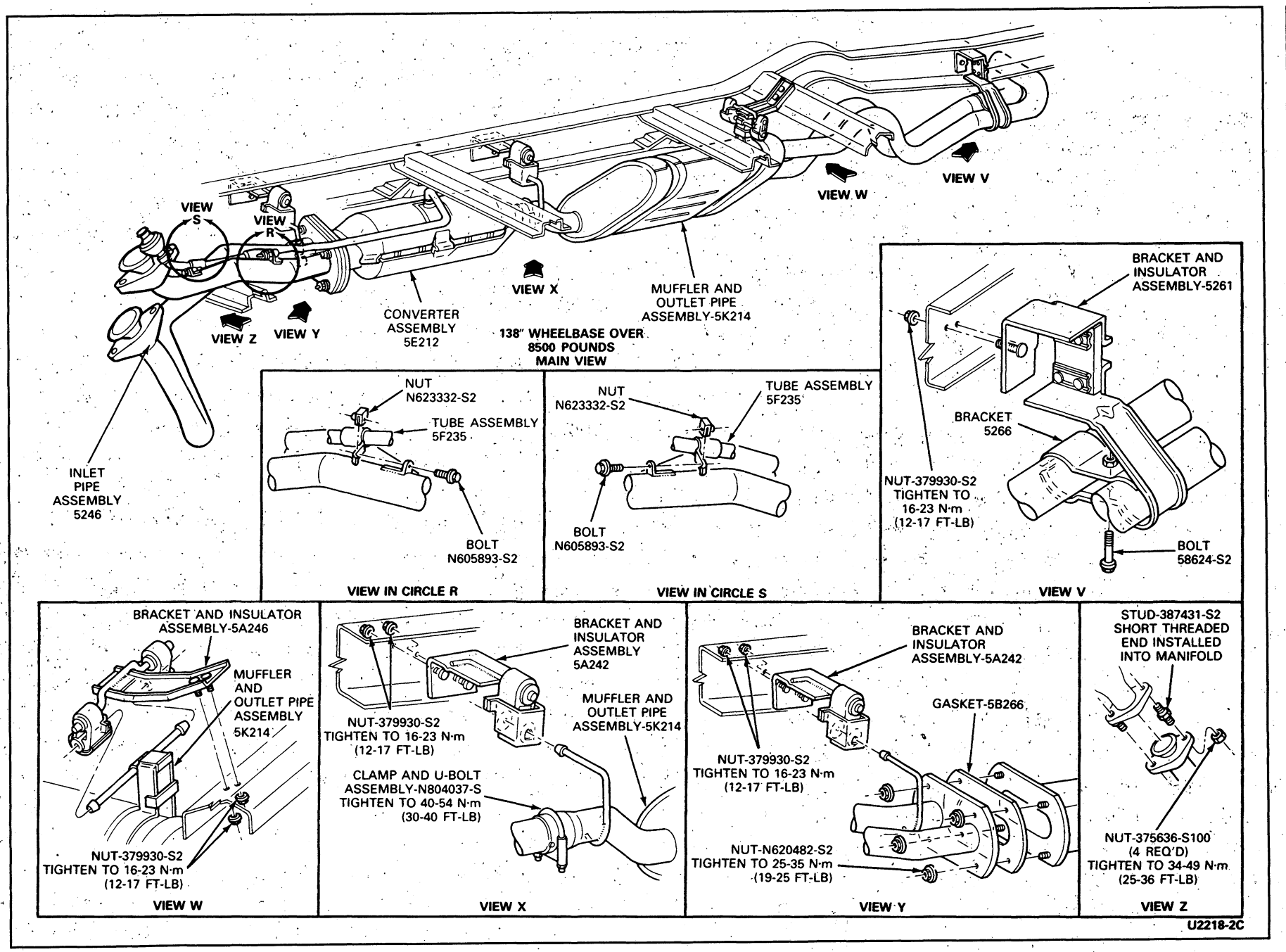


FIG. 9 E-250—E-350 5.8L (352 CID) EFI and 7.5L (460 CID) EFI Engine Exhaust Systems

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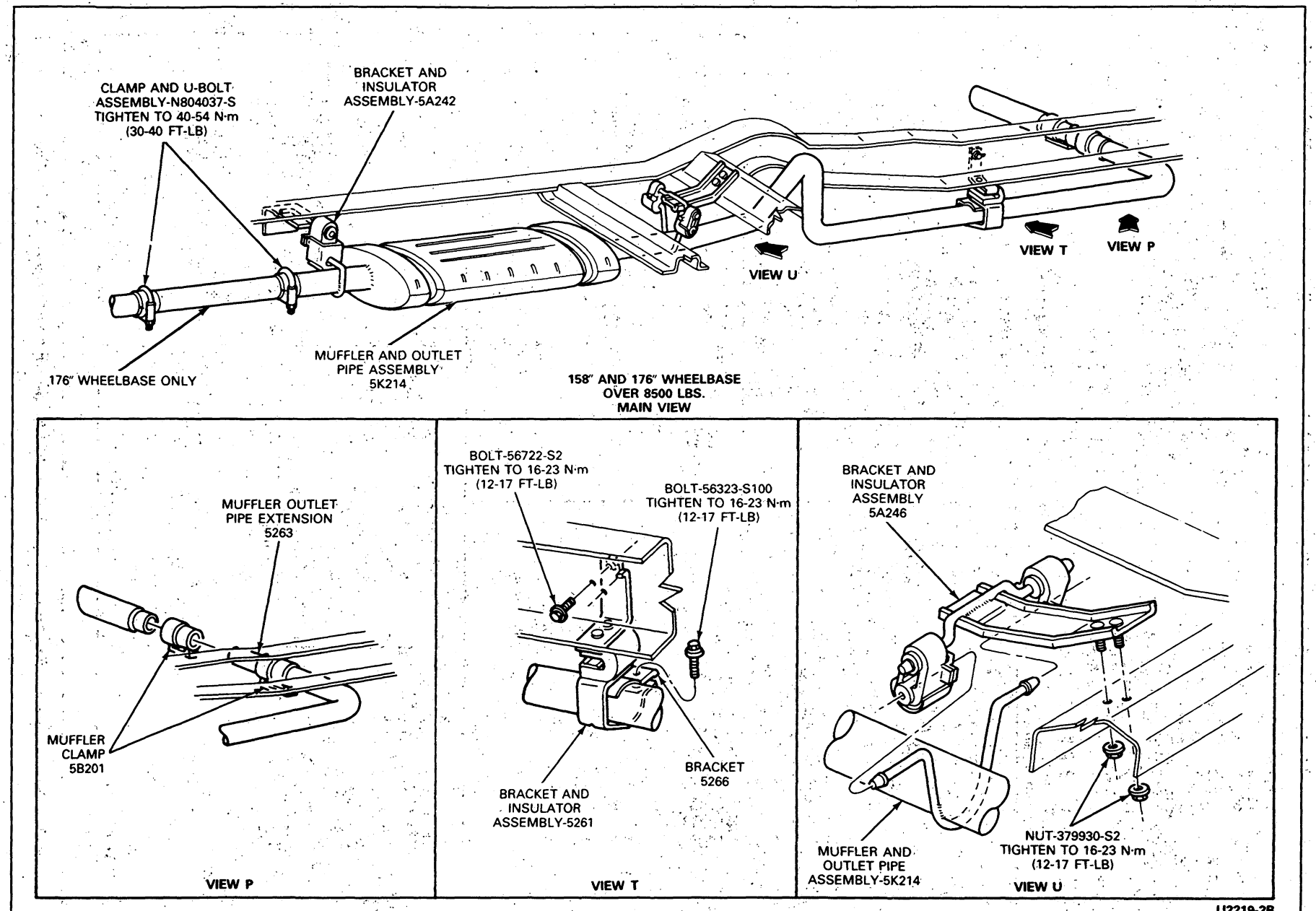


FIG. 9A E-250—E-350 5.8L (352 CID) EFI and 7.5L (460 CID) EFI Engine Exhaust Systems (Cont'd)

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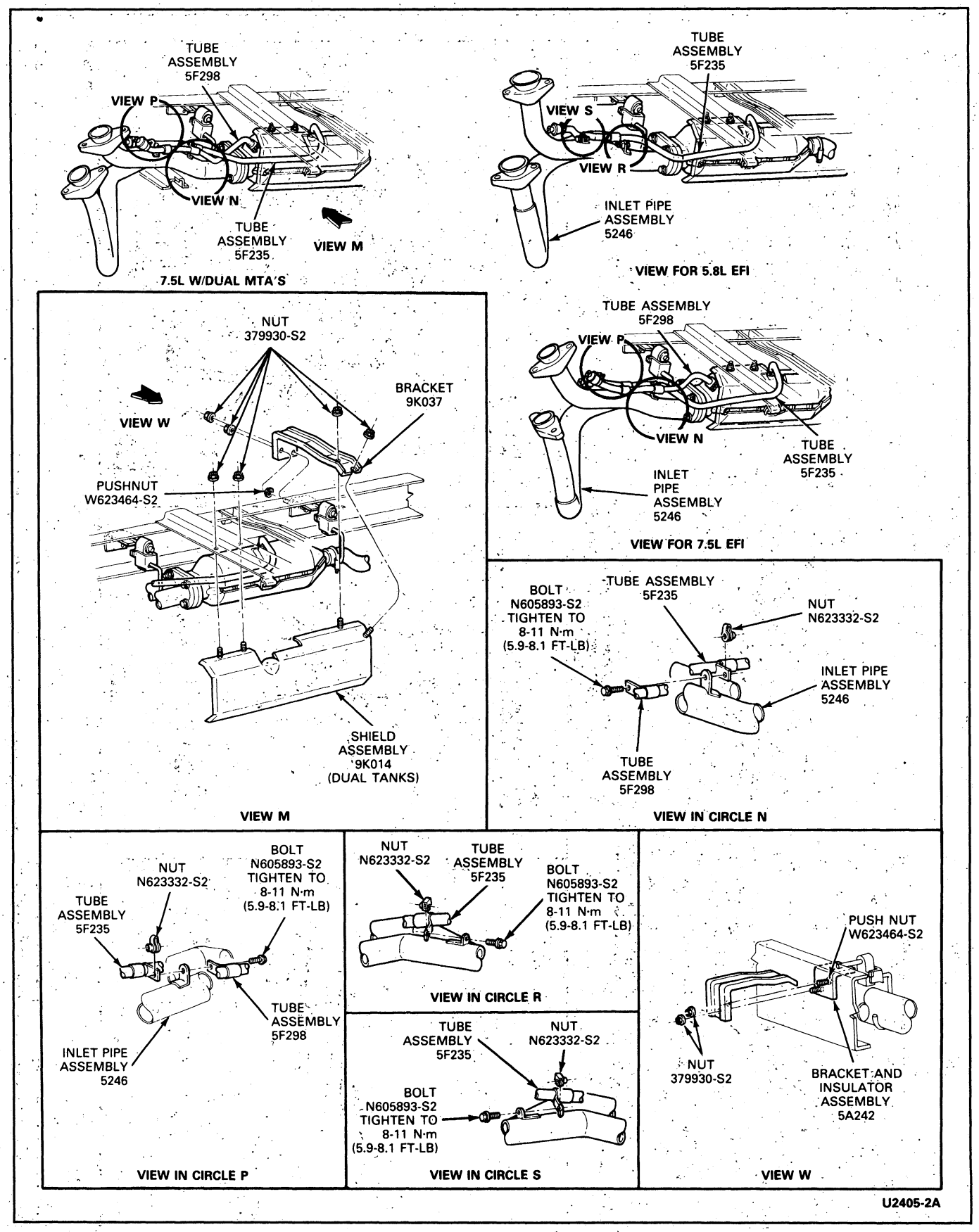


FIG. 9B E-250—E-350 5.8L (351 CID) EFI and 7.5L (460 CID) EFI Engine Exhaust Systems (Cont'd)

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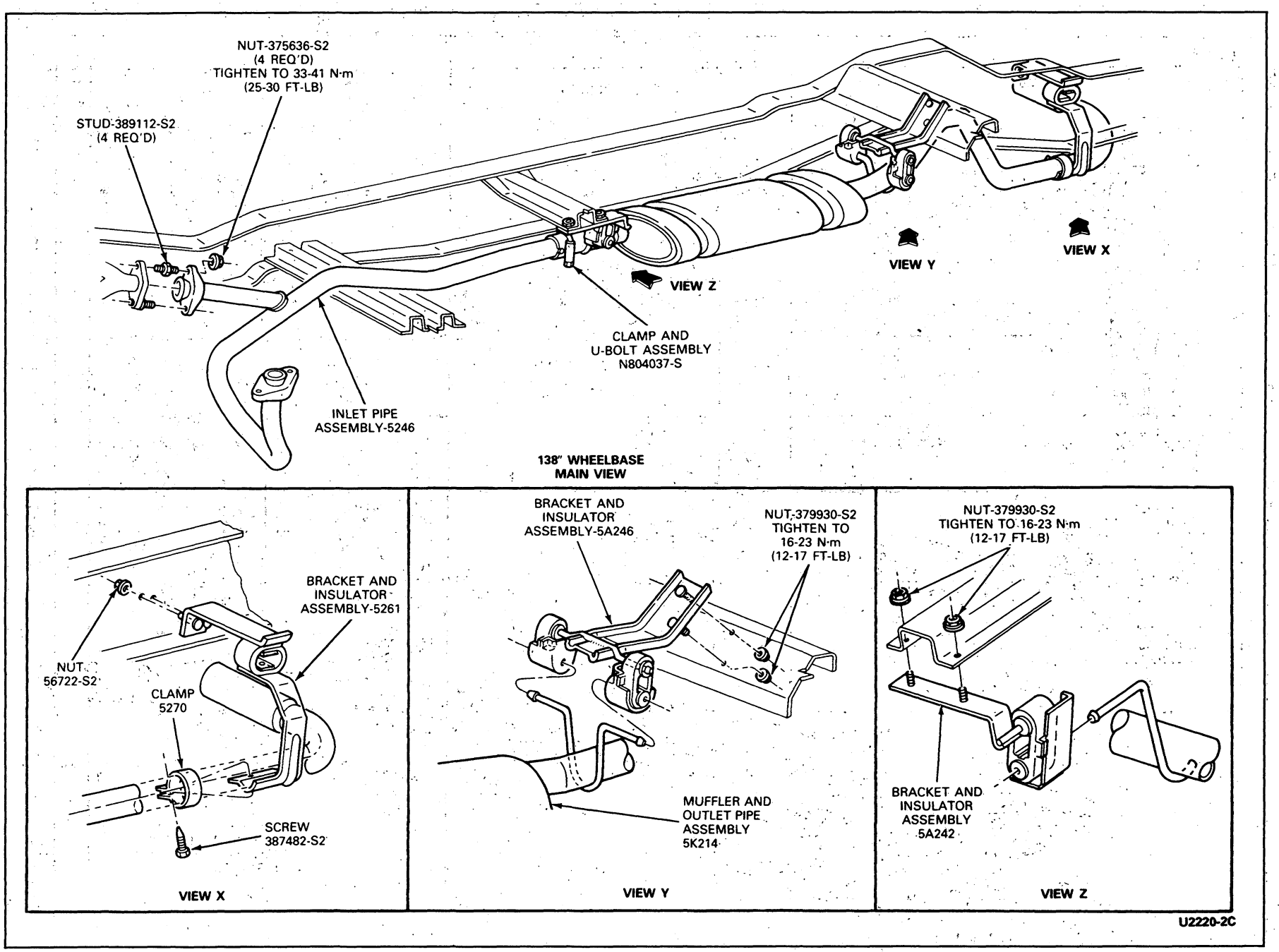


FIG. 10 E-250 Heavy Duty—E-350 7.3L Diesel Engine Exhaust Systems

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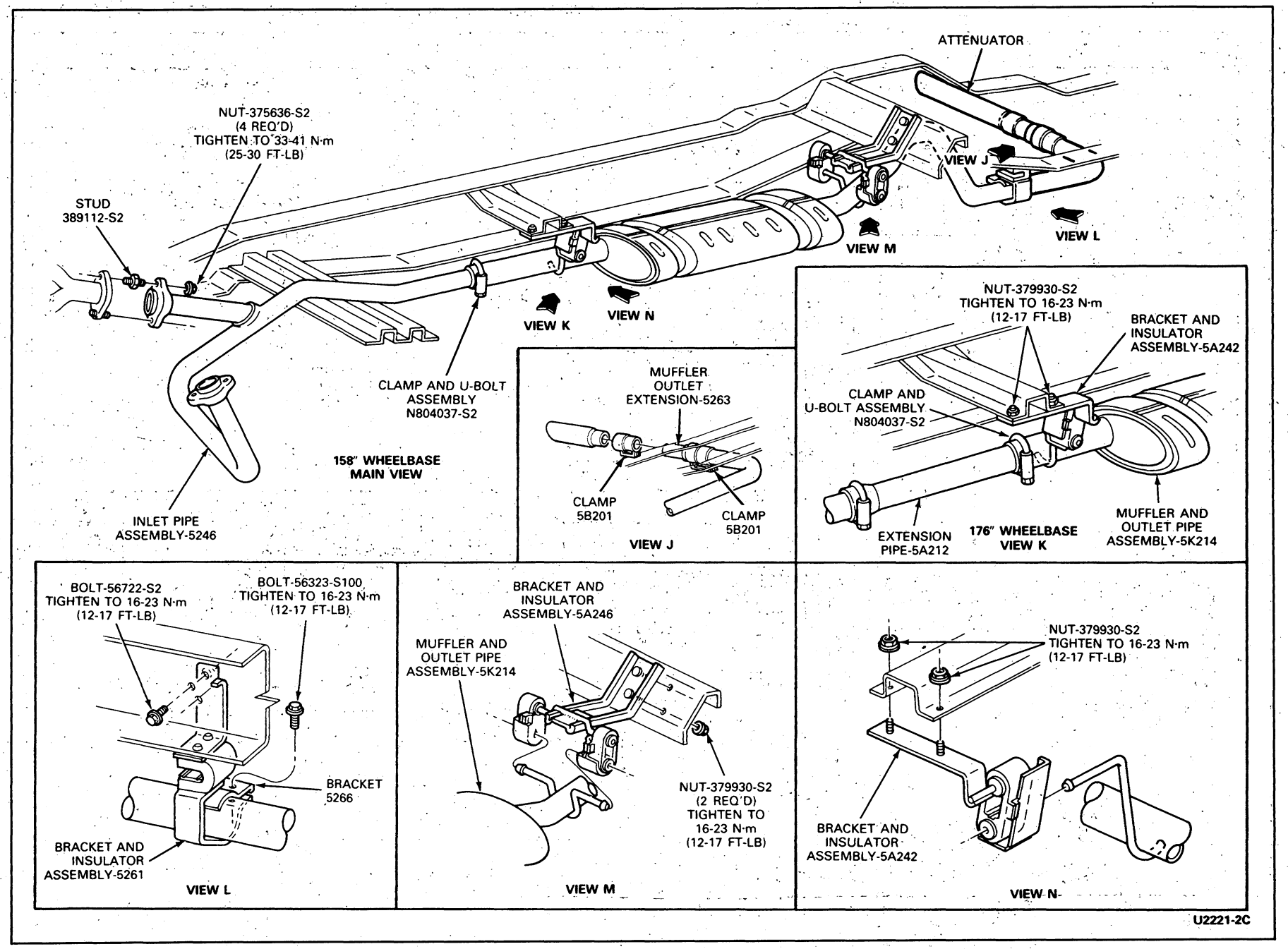


FIG. 10A E-250 Heavy Duty—E-350 7.3L Diesel Engine Exhaust Systems (Cont'd)

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SPECIFICATIONS

TORQUE LIMITS — EXHAUST SYSTEM BOLTS AND NUTS —

UNLESS OTHERWISE SPECIFIED, THE FOLLOWING TORQUE RANGES ARE TO BE USED FOR FITTING OR FASTENER DIAMETERS AS INDICATED.

Bolt or Nut Diameter	Torque Range	
	Class 9.8 (Grade 5)	Class 10.9 (Grade 8)
8mm (5/16 inch)	20-27 N•m (14-19 ft-lb)	26-35 N•m (20-25 ft-lb)
10mm (3/8 inch)	37-50 N•m (28-36 ft-lb)	47-64 N•m (34-47 ft-lb)
12mm (7/16 inch)	65-90 N•m (48-66 ft-lb)	80-110 N•m (59-80 ft-lb)

CU1988-1B

Item	Torque	
	N•m	Ft-Lb
Inlet Pipe to Exhaust Manifold	34-52	25-38
U-bolt (Managed Thermactor Air) M.T.A.	6.5-11	5-8
Inlet Pipe or Converter to Muffler or Extension (F-Series — Bronco)	49-61	35-45
Inlet Pipe or Converter to Muffler (E-Series)	41-54	30-40
Hanger Bracket and Insulator to Frame (F-Series — Bronco)	23-33	17-24
Hanger Bracket and Insulator to Frame (E-Series)	17-23	12-17
Bracket and Insulator to Exhaust (F-Series — Bronco)	17-23	12-17
Flat Flange Bolts (7.5L and 6.9L Engines)	31-43	23-32
Rear Hanger Bracket Clamp to Track Screw (E-Series)	10-14	7-11

CU2205-2A

SPECIAL SERVICE TOOLS

ROTUNDA EQUIPMENT

Model	Description
059-00008	Vacuum Gauge
059-00007	Tachometer

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GROUP 27 COOLING SYSTEM

(8000)

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COOLING SYSTEM SERVICE	27-02-1
FAN AND CLUTCH—ENGINE OPERATED	27-09-1
RADIATORS	27-04-1

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VEHICLE APPLICATION

All Models.

DESCRIPTION AND OPERATION

WARNING: DO NOT STAND IN LINE WITH OR NEAR RADIATOR FAN WHEN ENGINE IS RUNNING.

NOTE: Walter C. Avrea, the owner of patents 3, 601, 181 and RE27, 965, has granted Ford Motor Company rights with respect to cooling systems covered by these patents.

The correct coolant level is essential for maximum circulation and adequate cooling. In addition, for the cooling system to perform its function, it must receive proper care. This includes keeping the radiator fins clean and periodically inspecting the cooling system for leakage.

WARNING: NEVER REMOVE THE RADIATOR CAP UNDER ANY CONDITIONS WHILE THE ENGINE IS OPERATING. FAILURE TO FOLLOW THESE INSTRUCTIONS COULD RESULT IN DAMAGE TO THE COOLING SYSTEM OR ENGINE AND/OR PERSONAL INJURY. TO AVOID HAVING SCALDING HOT COOLANT OR STEAM BLOW OUT OF THE RADIATOR, USE EXTREME CARE WHEN REMOVING THE CAP FROM A HOT RADIATOR. WAIT UNTIL THE ENGINE HAS COOLED, THEN WRAP A THICK CLOTH AROUND THE RADIATOR CAP AND TURN IT SLOWLY TO THE FIRST STOP. STEP BACK WHILE THE PRESSURE IS RELEASED FROM THE COOLING SYSTEM. WHEN YOU ARE SURE ALL THE PRESSURE HAS BEEN RELEASED, PRESS DOWN ON THE CAP (STILL WITH A CLOTH), TURN AND REMOVE IT.

In production E-150—E-350, Bronco and F- 150—F-350 and F-Super Duty series vehicle cooling systems are filled with a 50/50 solution of Ford Cooling System Fluid and water which prevents corrosion, keeps the cooling system clean, provides antifreeze protection to -28.8 to -37.2°C (-20 to -35°F) in winter and provides for higher summer operation temperatures.

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NOTE: A coolant mixture of 50 percent coolant concentrate and 50 percent water is recommended to maintain best overall performance. To avoid damaging the radiator, the coolant concentrate should not exceed 60 percent.

For the most effective cooling system operation, this mixture strength should be maintained all year round and in all climates. Refer to Draining, Filling and Bleeding the Cooling System in this Section.

Coolant should be the specified mixture of Ford Premium Cooling System Fluid E2FZ-19549-AA or equivalent and water. If Ford Cooling System Fluid is not available, another reputable permanent antifreeze meeting Ford specification ESE-M97B44-A must be used and diluted with an equal quantity of tap water.

Ordinary tap water may be used in an emergency except in areas where the water is known to be exceptionally hard or to have a high alkali content. The cooling system should be drained and flushed and the proper mixture of antifreeze added as soon as possible.

To avoid possible overheating in very hot weather, do not use mixtures with more than 50 percent antifreeze except in areas where antifreeze protection below 1.7°C (35°F) is required. In this case, refer to the coolant mixture chart on the Ford Premium Cooling System Fluid container.

A standard ethylene glycol hydrometer or Rotunda Anti-Freeze Tester 021-00046 or equivalent can be used to check the protection level of the long-life coolant.

When water or antifreeze must be added to the cooling system during periods of below freezing ambient temperature, always operate the engine at fast idle for 30 minutes before letting the vehicle stand with the engine off for prolonged periods. This will create a uniform mixture throughout the cooling system and prevent damage by freezing, when sufficient antifreeze is used.

If the fan drive belt(s) is noisy, check the tension of the belt(s) to make certain it is within specifications. Also, check for misaligned pulleys. If the drive belt(s) is worn or frayed, replace it. Refer to Section 27-06, Accessory Drive Belt Service.

Coolant Recovery System

Coolant recovery systems are standard on F-150—F-350, F-Super Duty series vehicles and Bronco. It is also standard on E-250—E- 350 with 7.3L Diesel engine. Maintain the coolant level in the radiator flush with the cap seal in the filler neck to 38mm (1.5 inches) below the cap seal.

CAUTION: Do not remove the radiator cap when the cooling system is hot.

Thermostat

A poppet-type thermostat is used with all engines.

When the thermostat is closed, coolant flows to the water pump through a bypass passage at the front of the engine. When the thermostat is open, coolant flows through the coolant outlet elbow (thermostat housing) to the radiator.

The thermostat used in production is a high temperature thermostat for use with a mixture of water and permanent-type antifreeze. A low temperature thermostat should be installed if a non- permanent type antifreeze and water coolant solution is used (except on trucks with automatic radiator shutters).

DIAGNOSIS AND TESTING

Visual Inspection

A. Check for leaks at:
   1. All hoses and hose connections.
   2. Radiator seams, radiator core, and radiator drain petcock.
   3. All block core plugs and drain plugs.
   4. Edges of all other cooling system gaskets.
   5. Transmission oil cooler.
   6. Vehicle heating system components.
   7. Water pump.

B. Examine oil dipstick for evidence of engine oil contaminated with coolant.

C. Check radiator for evidence of oil in coolant (leakage at transmission oil cooler).

Install the analyzer from Rotunda Cooling System Pressurization Kit 021-00012 or equivalent to assist in testing the cooling system. Follow the manufacturer's recommended connections and testing procedures.

Cooling System Pressure Test

1. Shut the engine off.

WARNING: NEVER REMOVE THE RADIATOR CAP UNDER ANY CONDITIONS WHILE THE ENGINE IS OPERATING. FAILURE TO FOLLOW THESE INSTRUCTIONS COULD RESULT IN DAMAGE TO THE COOLING SYSTEM OR ENGINE AND/OR PERSONAL INJURY. TO AVOID HAVING SCALDING HOT COOLANT OR STEAM BLOW OUT OF THE RADIATOR, USE EXTREME CARE WHEN REMOVING THE CAP FROM A HOT RADIATOR. WAIT UNTIL THE ENGINE HAS COOLED, THEN WRAP A THICK CLOTH AROUND THE RADIATOR CAP AND TURN IT SLOWLY TO THE FIRST STOP. STEP BACK WHILE THE PRESSURE IS RELEASED FROM THE COOLING SYSTEM. WHEN YOU ARE SURE ALL THE PRESSURE HAS BEEN RELEASED, PRESS DOWN ON THE CAP (STILL WITH A CLOTH), TURN AND REMOVE IT.

2. Adjust the radiator coolant (fill or drain) to 25mm (one inch) below the filler neck opening before testing. Wipe clean and wet the rubber sealing surface of the cap before installing the cap tightly on the radiator.
3. Disconnect the electrical connector from the coolant temperature sending unit and remove the temperature sending unit from the engine.

   With the radiator cap installed and the cooling system pressure relieved, only a small amount of coolant will be lost when the sending unit is removed.
4. Install the adapter fitting from Rotunda Cooling System Pressurization Kit 021-00012 or equivalent (male thread on one end, and a hose connector on the other end to accommodate the tester hose) tightly into the intake manifold or cylinder head in place of the sending unit. Refer to Fig. 1.
5. On E-150—E-350, remove the radiator overflow hose from the retainer clips. If vehicle is equipped with an expansion bottle system, use a separate

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hose. Make sure the hose is firmly installed on the radiator overflow nipple and is in good condition. Insert the free end of the overflow hose into a container of water.

6. On Bronco and F-150—F-350 and F-Super Duty, series vehicles, remove the radiator overflow hose from the overflow nipple. Install a separate hose firmly on the overflow nipple. Insert the free end of separate hose into container of water.
7. Attach the pressure pump and gauge (Fig. 1) to the adapter-fitting and pressurize the cooling system to the cap LOWER LIMIT as shown in the test chart.

   No bubbles should appear in the water container when the system is pressurized to the LOWER LIMIT. If the system is satisfactory at the lower limit, gradually increase the system pressure until a slight stream of bubbles appears in the water container. This is the release pressure of the pressure cap.

   Replace any radiator cap which has a release pressure that is greater than the specified UPPER LIMIT pressure without discharging bubbles. Refer to Specifications at the end of Section 27-04, Radiators.
8. If the radiator cap does not hold pressure, remove and wash the cap in clean water to dislodge all foreign particles from the gaskets. Check the sealing surface in the radiator filler neck.

   Inspect the cam lock flanges on both sides of the filler neck for maximum cap engagement.
9. Pressurize the cooling system as outlined in Step 7 (using a radiator cap that operates within the specified upper and lower pressure limits) and observe the gauge reading for approximately two minutes. Pressure should be held between 69 and 89 kPa (10 and 13 psi) and should not drop during this time.

   RESULTS: If the pressure drops, check for leaks at the engine-to-heater core hoses, engine-to-radiator hoses, bypass hose, water valve hose (if applicable), thermostat housing gasket, radiator and heater core, etc. Also refer to engine system checks if a leak cannot be located in the cooling system. Any leaks which are found must be corrected and the system checked again.

   If the system holds pressure proceed to Step 10.
10. Release the system pressure by loosening the radiator cap and removing the adapter. Install the temperature sending unit, check coolant level and replenish, if necessary, with the correct coolant solution.

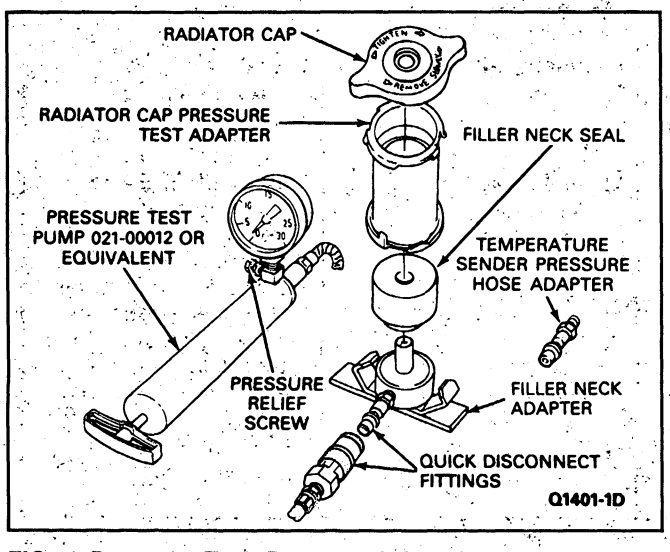


FIG. 1 Pressure Test Pump and Attachments

Radiator Cap Pressure Test

Refer to Fig. 1.

1. Remove the radiator cap from the radiator filler neck.
2. Use water to clean the cap in the area of the rubber seal and the vacuum relief valve as outlined. Immerse the radiator cap in water to wet the seals and install on the shallow filler neck of Rotunda Radiator Cap Pressure Test Adapter 021-00012 or equivalent adapter.

   NOTE: The adapter is designed to accept both deep and shallow neck radiator caps.
3. Immerse the filler neck seal in water and install in the filler neck adapter.

   NOTE: The filler neck seal is reversible so that it may be used on either a deep or shallow radiator filler neck. It will also fit either end of the radiator cap pressure test adapter.
4. Install the filler neck adapter with filler neck seal on the deep filler neck end to the radiator cap pressure test adapter.
5. Connect the female quick disconnect fitting of the pressure test pump to the male quick disconnect fitting of the filler neck adapter.
6. SLOWLY depress the plunger of the pressure test pump until the pressure gauge reading stops increasing and note the highest pressure reading obtained.

   NOTE: If the plunger of the pump is depressed too fast, an erroneous pressure reading will result.
7. Release the pressure by turning the pressure relief screw counterclockwise. Then, tighten the pressure relief screw and repeat Step 6 (at least twice) to ensure the pressure test reading is repeatable within the acceptable gauge reading limits of the radiator cap and is not erratic. Refer to Specifications at end of Section 27-04, Radiators.
8. If the pressure test gauge readings are not within the acceptable gauge reading limits, replace the radiator cap, and perform a cooling system pressure test. If the pressure test gauge readings are within the acceptable gauge reading limits, perform the Cooling System Pressure Test.

Thermostat Test

If the problem being investigated is insufficient heat, inspect the thermostat for leakage. This may be done by holding the thermostat up to a lighted background. Light leakage around the thermostat valve (thermostat at room temperature) is unacceptable and the thermostat should be replaced. It is possible, on some thermostats, that a slight leakage of light at one or two locations on the perimeter of the valve may be detected. This should be considered normal.

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Diagnosis

Refer to the following Diagnosis Guides for cooling system complaints, their possible cause and recommended resolution. Refer to the pertinent Section for testing and service.

Use a cooling system analyzer or equivalent to assist in diagnosing the cooling system. Follow the manufacturers instructions for connections at testing.

The most frequent cooling system complaints concern leakage and overheating. Either of these problems will soon render the vehicle inoperable.

Most vehicles use an ethylene glycol base antifreeze solution to which the manufacturers have added a dye color. The dye color makes the antifreeze solution an excellent leak detector. If this type of solution is not being used in the cooling system, a vegetable dye may be added to aid in locating external leakage.

Draining, Filling and Bleeding the Cooling System

To prevent loss of coolant when draining the radiator, attach a hose on the radiator draincock and drain the coolant from the radiator into a clean container.

To drain the radiator, open the draincock located at the bottom of the radiator and remove the radiator cap or supply tank cap. The cylinder block of the V-8 engine is drained by removing the drain plugs located on both sides of the block. The 6-cylinder engines have one drain plug located at the left rear of the cylinder block.

To fill the cooling system, install the cylinder block drain plug(s) and close the radiator draincock. Disconnect the heater outlet hose at the water pump to bleed or release trapped air in the system. When the coolant begins to escape, connect the heater outlet hose.

Fill the radiator until the coolant is between the cap seal in the filler neck to 38mm (1.5 inches) below the cap seal. Install cap.

WARNING: DO NOT STAND IN LINE WITH OR NEAR ENGINE COOLING FAN WHEN ENGINE IS RUNNING.

Start engine, warm up, shut off engine. Allow engine to cool, remove cap and check coolant level. Fill as required.

WARNING: NEVER REMOVE THE RADIATOR CAP UNDER ANY CONDITIONS WHILE THE ENGINE IS OPERATING. FAILURE TO FOLLOW THESE INSTRUCTIONS COULD RESULT IN DAMAGE TO

Diagnosis Guides

LOSS OF COOLANT DIAGNOSIS GUIDE

TEST STEP		RESULT ▶	ACTION TO TAKE
A0	VISUAL CHECK		
• Make visual check for leaking hoses, and connections to radiator, heater core and engine.		(OK) ▶	GO to **A1**.
		(OK) ▶	Make necessary repairs. GO to **A1**.
A1	PRESSURE TEST		
• Pressure test cooling system to check for dirty or damaged radiator cap, external leakage and/or internal leakage.		(OK) ▶	RETURN vehicle to customer.
		Dirty or damaged radiator cap ▶	CLEAN or REPLACE cap. REPEAT **A1**.
		External Leak ▶	REPAIR or REPLACE as necessary. REPEAT **A1**.
		Internal Leak ▶	DISASSEMBLE engine as necessary to determine cause of leakage. CHECK for: cracked intake manifold, blown head gasket, warped block or head gasket surfaces, cracked cylinder head(s), cracked cylinder block. REPAIR or REPLACE as necessary. REPEAT **A1**.

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ENGINE FAILS TO REACH NORMAL OPERATING TEMPERATURE DIAGNOSIS GUIDE

TEST STEP		RESULT	ACTION TO TAKE
B0	TEMPERATURE CHECK (DOWN FLOW RADIATOR ONLY)		
	• Operate engine at high RPM or under load for 20 minutes. Check coolant temperature with thermometer. **WARNING: USE CARE WHEN REMOVING RADIATOR CAP TO AVOID INJURY FROM ESCAPING STEAM OR HOT WATER.** **NOTE:** Remove radiator cap before running this test. Then use a known quality thermometer for checking coolant temperature.	(OK) ▶	GO to **B1**.
		(OK) ▶	GO to **B2**.
B1	GAUGES/LIGHTS		
	• Check operation of temperature gauge (Refer to Section 33-41, Temperature Indicators, of the Body, Chassis and Electrical Manual).	(OK) ▶	RELEASE vehicle to customer.
		(OK) ▶	REPAIR or REPLACE components as necessary.
B2	THERMOSTAT		
	• Remove and test thermostat. (Refer to Thermostat Testing, in this Section.)	(OK) ▶	RELEASE vehicle to customer.
		(OK) ▶	REPLACE the thermostat. GO to **B0**.

CQ1702-2D

THE COOLING SYSTEM OR ENGINE AND/OR PERSONAL INJURY. TO AVOID HAVING SCALDING HOT COOLANT OR STEAM BLOW OUT OF THE RADIATOR, USE EXTREME CARE WHEN REMOVING THE CAP FROM A HOT RADIATOR. WAIT UNTIL THE ENGINE HAS COOLED, THEN WRAP A THICK CLOTH AROUND THE RADIATOR CAP AND TURN IT SLOWLY TO THE FIRST STOP. STEP BACK WHILE THE PRESSURE IS RELEASED FROM THE COOLING SYSTEM. WHEN YOU ARE SURE ALL THE PRESSURE HAS BEEN RELEASED, PRESS DOWN ON THE CAP (STILL WITH A CLOTH), TURN AND REMOVE IT.

CLEANING AND INSPECTION

Radiator Coolant Level Check

Engine should be at normal operating temperature.

In addition to maintaining the correct coolant level, the radiator fins must be cleaned and the cooling system inspected periodically for leaks in order to be sure the system operates at maximum efficiency.

Check the cooling system for dirty or rusty appearance. Dirty or rusty coolant requires replacement to protect the cooling system from corrosion damage.

Cleaning Cooling System

To remove rust, sludge and other foreign material from the cooling system, use Ford Premium Cooling System Flush D6AZ-19A503-AA or equivalent. Removal of such material restores cooling efficiency and avoids overheating. **Always remove the thermostat prior to pressure flushing. A pulsating or reversed direction of flushing water flow will loosen sediment more quickly than a steady flow in the normal direction of coolant flow. In severe cases where cleaning solvents will not properly clean the cooling system for efficient operation, it will be necessary to use the pressure flushing method. Various types of flushing equipment are available.**

Do not back-flush cooling systems that have a water shutoff valve in the heater system, or damage to the valve can result.

CAUTION: Do not rod out the copper/brass diesel radiator. The tubes have integral turbulators embossed into them and damage to the tubes will result.

Heater Core Back-Flushing

All engine cooling system flushing and back-flushing procedures must include a separate back-flushing of the heater or A/C-Heater system heater core, after the flushing or back-flushing of the engine cooling system. This will prevent engine cooling system particles from clogging the heater core tubes and reducing (or eliminating) coolant flow through the heater core.

The heater core must be back-flushed separately from the engine cooling system for proper back-flush water flow direction through the heater core.

The correct heater core back-flushing procedure is as follows:

1. On F-Series and Bronco vehicles, disconnect the heater core outlet heater hose from the water pump fitting and install a female garden hose-end

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ENGINE OVERHEATS DIAGNOSIS GUIDE

	TEST STEP	RESULT ▶	ACTION TO TAKE
C0	COOLANT		
	• Check coolant level.	(OK) ▶	GO to **C1**.
		(OK) ▶	REFER to Coolant Loss Diagnosis Guide in this Section. GO to **C1**.
C1	TEMPERATURE CHECK — (DOWN FLOW RADIATOR ONLY)		
	• Operate engine at high RPM or under load for 20 minutes. Check temperature with a thermometer. **CAUTION: USE CARE WHEN REMOVING RADIATOR CAP TO AVOID INJURY FROM ESCAPING STEAM OR HOT WATER. IF ENGINE OVERHEATS, SHUT DOWN IMMEDIATELY AND GO TO C3.** **NOTE:** Remove radiator cap before running this test.	(OK) ▶	GO to **C2**.
		Temperature too low ▶	GO to Engine Fails to Reach Normal Operating Temperature Diagnosis Guide in this Section.
		Temperature too high ▶	GO to **C3**.
C2	TEMPERATURE GAUGE		
	• Check operation of temperature gauge. (Refer to Section 33-41, Temperature Indicators, of the Body, Chassis and Electrical Manual).	(OK) ▶	RELEASE Vehicle to customer.
		(OK) ▶	REPAIR or REPLACE components as necessary.
C3	FAN BELT		
	• Check fan belt tension. (Refer to Section 27-06, Accessory Drive Belt Service, in this Manual.)	(OK) ▶	GO to **C4**.
		(OK) ▶	REPLACE fan belt and/or ADJUST belt tension. GO to **C1**.

CQ2133-2C

fitting adapter in the end of the outlet heater hose. Secure with a hose clamp.

On Econoline vehicles, disconnect the heater core outlet hose from the heater core (Fig. 2). Then, fabricate a jumper hose with a Quick Connect Coupling Assembly (Part No. 18D535) on one end and a female garden hose fitting on the other end. Attach the jumper hose to the heater core outlet tube.

2. Connect the female garden hose-end of the outlet heater hose to the male end of a water supply garden hose.
3. Disconnect the heater core inlet heater hose from the engine block fitting and allow to drain onto the ground or into a floor drain.
4. If a water valve is installed in the heater core inlet heater hose, check to be certain the water valve is open (no vacuum).
5. Turn the water supply valve on and off several times so that the surge action will help to dislodge larger stubborn particles from the heater core tubes. Allow full water pressure to flow for approximately five minutes.
6. If a water valve is installed in the heater core inlet heater hose, apply vacuum to the water valve vacuum motor to ensure proper operation of the water valve and proper closure with no water leakage. Replace the water valve if required.
7. Remove the hose clamp and female garden hose-end adapter from the end of the outlet heater hose and connect the outlet heater hose onto the water pump fitting.
8. Connect the inlet heater hose onto the engine block fitting.
9. Fill the cooling system, as outlined.
10. Test the system for proper heater performance with the specified engine cooling system conditions.

Radiator Pressure Cap

1. Inspect the areas under the vacuum valve and rubber seal for rust or dirt particles (Fig. 4).

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ENGINE OVERHEATS DIAGNOSIS GUIDE (Continued)

TEST STEP	RESULT	ACTION TO TAKE
C4 RADIATOR • Check radiator fins for obstructions.	OK ▶	GO to **C5**.
	NOT OK ▶	CLEAR radiator fins. GO to **C1**.
C5 SYSTEM CIRCULATION • Remove radiator cap. Operate engine at high RPM. Coolant should not overflow radiator filler neck.	OK ▶	GO to **C6**.
	NOT OK ▶	GO to **C8**.
C6 DISTRIBUTOR BASICS • Check ignition initial timing and distributor advance. (Refer to the Technical Service Bulletin Special Specifications Issue for distributors.)	OK ▶	GO to **C7**.
	NOT OK ▶	MAKE adjustments, repairs, and/or parts replacements as necessary. GO to **C1**.
C7 WATER PUMP • Remove water pump and check for binding or sheared impeller shaft.	OK ▶	REINSTALL water pump and RELEASE vehicle to customer.
	NOT OK ▶	REPLACE water pump. GO to **C1**.
C8 THERMOSTAT • Check thermostat operation. (Refer to Thermostat Test in this Section).	OK ▶	GO to **C9**.
	NOT OK ▶	REPLACE thermostat. GO to **C1**.
C9 COOLING SYSTEM • Flush, clean and refill cooling system. (Refer to Cleaning and Inspection in this Section.) Repeat test step **C1**.	OK ▶	RELEASE vehicle to customer.
	NOT OK ▶	GO to **C10**.
C10 FAN CLUTCH • Check automatic fan drive system operation. (Refer to Section 27-09, Radiators, in this Manual.)	OK ▶	RELEASE vehicle to customer.
	NOT OK ▶	REPLACE fan clutch and GO to **C1**.

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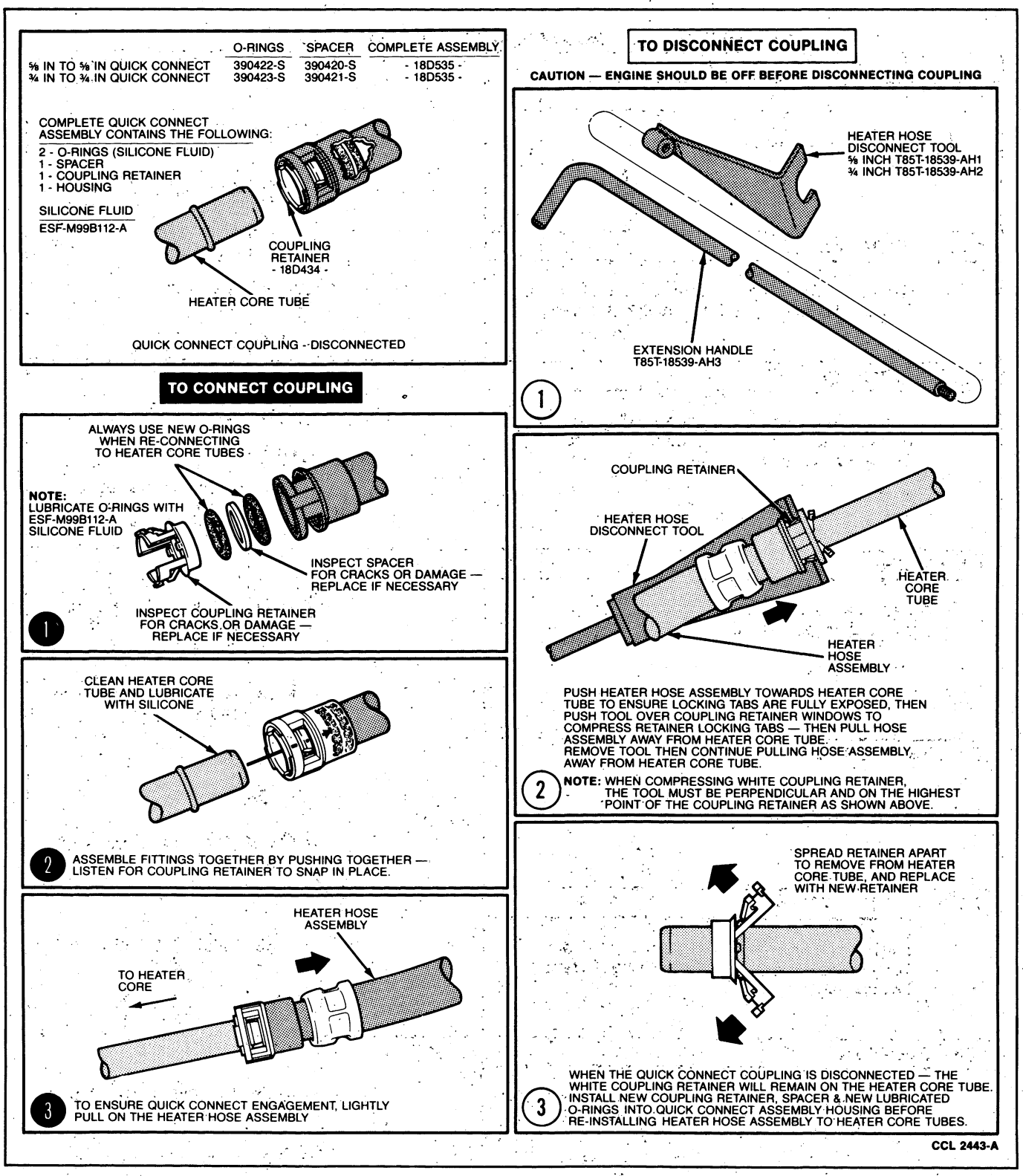


FIG. 2 Heater Hose Quick Connect Coupling

2. Use warm tap water, raise the vacuum valve and rubber seal and thoroughly flush away loose rust or dirt particles trapped under the vacuum valve, rubber seal and on the seal surface.
3. Inspect and remove any imbedded rust or dirt particles on the sealing surfaces of the rubber seal.
4. Inspect the radiator filler neck opening for rust or dirt particles on the sealing surface at the bottom of the filler neck opening. Use a clean cloth and wipe the sealing surface to remove any rust or dirt particles.

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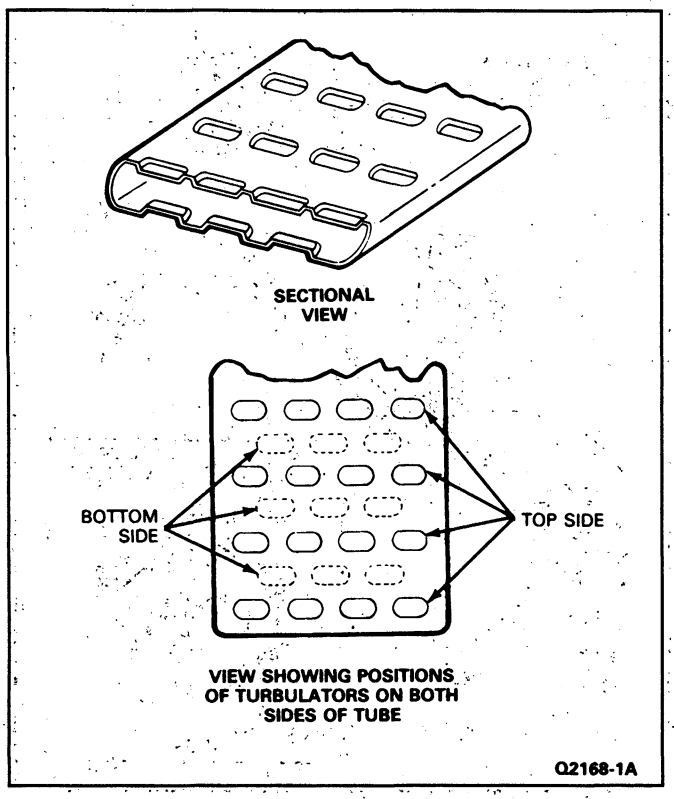


FIG. 3 Radiator Integral Turbulated Tube

NOTE: If paint is observed on the filler neck sealing surface, remove it using paint thinner.

REMOVAL AND INSTALLATION

Thermostat

Do not attempt to service the thermostat. It should be replaced if it is not operating properly.

Check the thermostat before installing it, following the Thermostat Test procedures.

4.9L (300 CID) I-6

Removal

1. Drain the radiator so that the coolant level is below the thermostat.
2. Remove the coolant outlet elbow attaching bolts (Fig. 5). Pull the elbow away from the cylinder head sufficiently to provide access to the thermostat. Remove the thermostat and gasket.

Installation

1. Clean the coolant outlet elbow and cylinder head gasket surfaces. Coat a new gasket with water-resistant sealer. Position the gasket on the cylinder head opening. The gasket must be positioned on the cylinder head before the thermostat is installed.
2. The coolant outlet elbow contains a locking recess into which the thermostat is turned and locked. Install the thermostat with the bridge section in the outlet elbow. Turn the thermostat clockwise to lock it in position on the flats cast into the outlet elbow.
3. Position the coolant outlet elbow against the cylinder head. Install and tighten the attaching bolts. Refer to Specifications.

   WARNING: DO NOT STAND IN LINE WITH OR NEAR RADIATOR FAN WHEN ENGINE IS RUNNING.
4. Fill and bleed the cooling system as outlined. Check for leaks and proper coolant level after the engine has reached normal operating temperatures.

V-8

Removal

1. Drain the radiator so that the coolant level is below the thermostat.
2. Disconnect the bypass hoses at the water pump and intake manifold. Remove the bypass tube. Remove the water outlet housing attaching bolts (Fig. 6). Bend the radiator upper hose upward and remove the thermostat and gasket.

Installation

1. Clean the water outlet housing gasket surfaces. Coat a new water outlet housing gasket with Perfect Seal Sealing Compound B5A-19554-A or equivalent. Position the water outlet housing gasket on the intake manifold opening.
2. Install the thermostat in the intake manifold opening with the copper pellet or element toward the engine and the thermostat flange positioned in the recess. If the thermostat is improperly installed, it will cause a retarded flow of coolant.
3. Position the water outlet housing against the intake manifold. Install and tighten the attaching bolts. Refer to Specifications. Install the water bypass line and tighten hose connections.

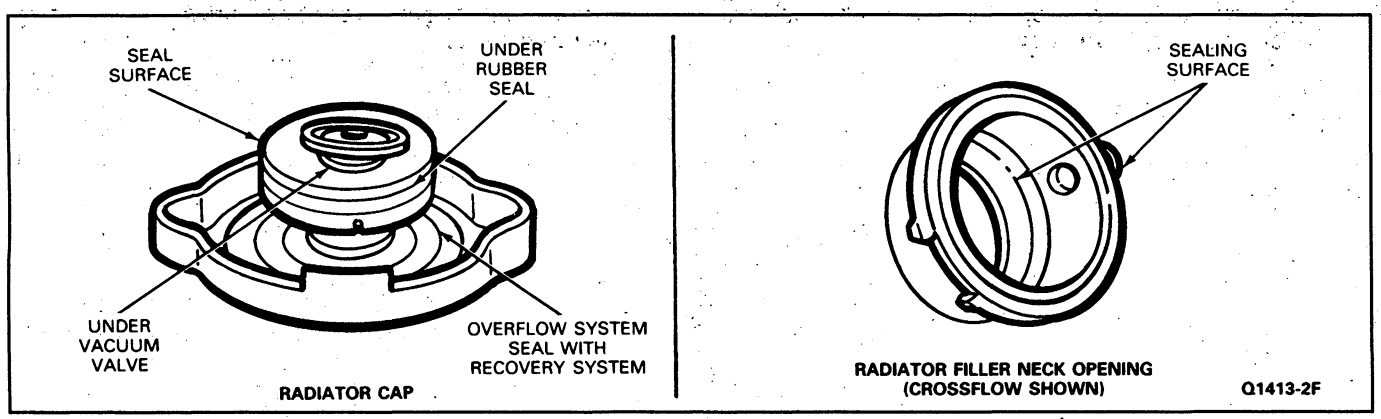


FIG. 4 Cleaning and Inspecting Radiator Cap and Filler Neck Opening

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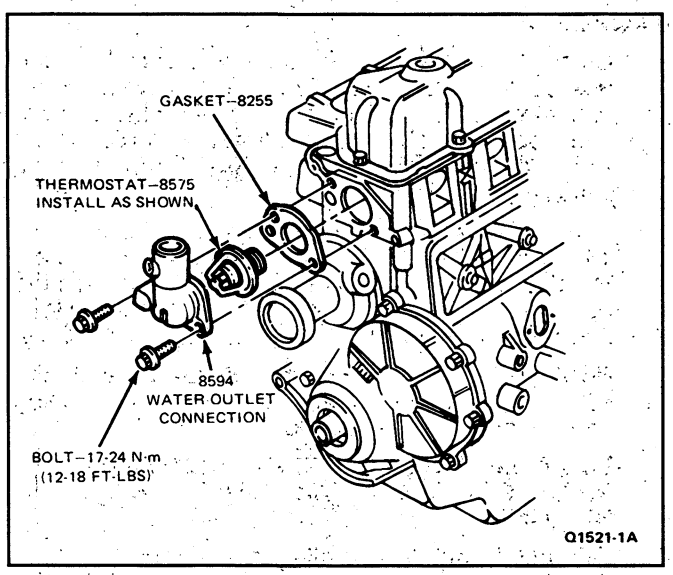


FIG. 5 4.9L (300 CID) Engine Thermostat Installation

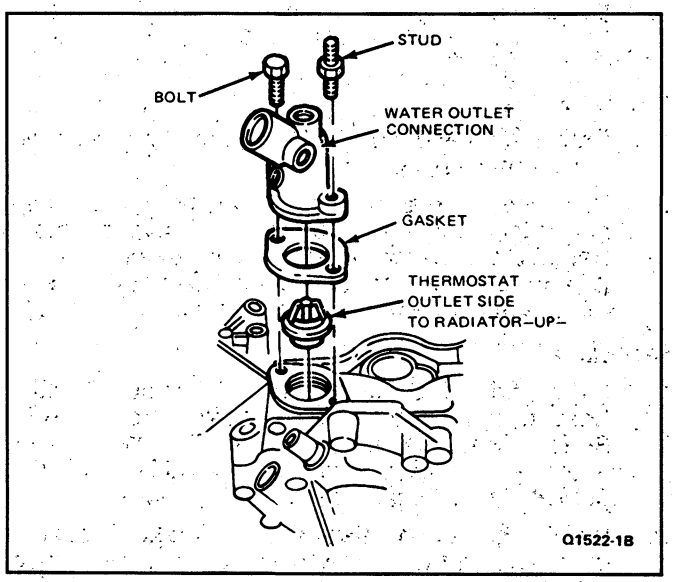


FIG. 6 V-8 Engine Thermostat Installation—Typical

WARNING: DO NOT STAND IN LINE WITH OR NEAR RADIATOR FAN WHEN ENGINE IS RUNNING.

4. Fill and bleed the cooling system as outlined. Operate the engine until normal operating temperature is reached; then check the coolant level and check for leaks.

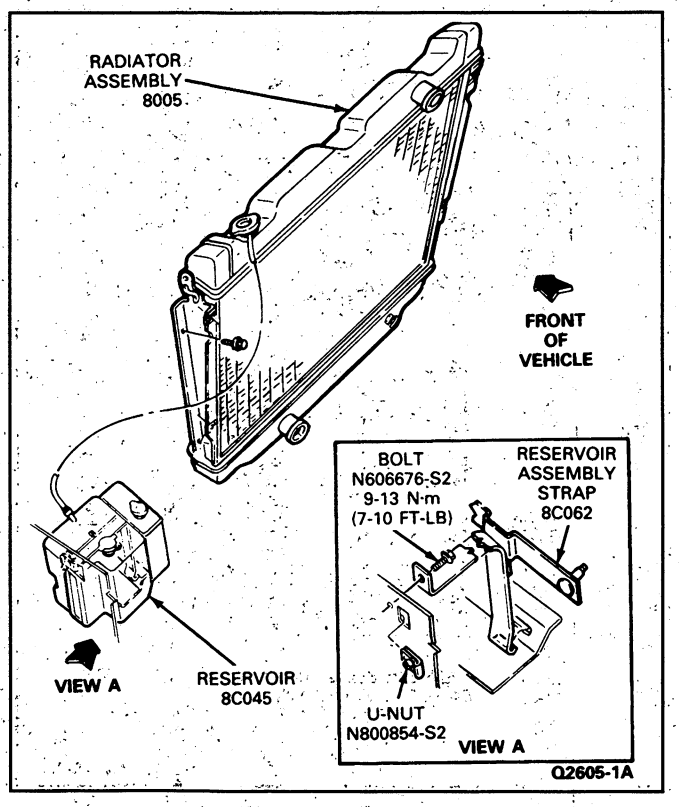


FIG. 7 E-250—E-350 With 7.3L Diesel Shown

Coolant Recovery Bottle

Removal

1. Drain the radiator until the coolant is out of the recovery bottle. Disconnect the radiator overflow line at the recovery bottle (Fig. 7).
2. Remove the overflow tube from the recovery bottle. Remove the recovery bottle strap or bracket attaching bolt(s) and remove the recovery bottle.

Installation

1. Position the recovery bottle in the chassis and install the strap or bracket attaching bolt(s).
2. Connect the overflow tube to the recovery bottle.

WARNING: DO NOT STAND IN LINE WITH OR NEAR RADIATOR FAN WHEN ENGINE IS RUNNING.

3. Fill and bleed the cooling system as outlined. Check for coolant leaks and proper coolant level after the engine reaches normal operating temperatures.

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SPECIFICATIONS

ENGINE COOLING SYSTEM REFILL CAPACITIES — F-150 THROUGH F-350, BRONCO, F-SUPER DUTY SERIES, AND E-150 THROUGH E-350 — DIESEL

Engine	Truck Model/Type	Equipment	Approximate Capacity		
			U.S. Quarts	Imperial Quarts	Liters
4.9L (300 CID) I-6	F-150/350, F-Super Duty & Bronco	Manual and Auto. Trans. — Standard	13	10	12
		Manual Trans. with A/C or Super Cool Auto. Trans. with Super Cool or Standard	14	11	13
		Manual Trans. with A/C and Super Cool Auto. Trans. with A/C and Super Cool or just A/C	15	12	14
5.0L (302 CID) V-8	F-150/250 Bronco	Manual Trans. — Standard	13	10	12
		Manual and Auto. Trans. with A/C Auto. Trans. — Standard	14	11	13
		Manual and Auto. Trans. with Super Cool or Super Cool and A/C	15	12	14
5.8L (351 CID) V-8	F-150/350 Bronco	Manual Trans. — Standard	15	12	14
		Auto. Trans. — Standard or A/C, Manual Trans. with A/C	16	13	15
		Manual and Auto. Trans. with Super Cool or Super Cool and A/C	17	14	16
7.5L (460 CID) V-8	F-250/350, F-Super Duty Chassis Cab and Motor Home Chassis Vehicles	All options	18	15	17
7.3L Diesel	F-250/350 and F-Super Duty Chassis Cab and Commercial Stripped Chassis	All options	29①	23①	27①
	E-250/350	All options	31①	25①	29①

①Include 5 quarts (or equivalent liters or Imperial quarts) in reservoir bottle.

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ENGINE COOLING SYSTEM REFILL CAPACITIES — E-150 THROUGH E-350 GASOLINE

Model	Engine	Vehicle Equipment	Approximate Capacities①②		
			U.S. Qts.	Imp. Qts.	Liters
All	4.9L EFI (300 CID) Six	Manual and Auto. Trans. Without Air Conditioning	15	12.5	14.2
		Manual and Auto. Trans. With Air Conditioning or Super Cooling	18	14.5	16
E-150 E-250	5.0L EFI (302 CID) V-8	Standard and Air Conditioning	17.5	14.0	16.6
		Super Cooling	18.5	15.3	17.5
E-150 E-250 E-350	5.8L (351 W CID) V-8	Standard Cooling	20	16	19
		Air Conditioning or Super Cooling	21	16.8	20
E-350	7.5L (460 CID) V-8	All Options	28	23	26

①Add 1 quart (U.S.) for heater.
②Add 1.8 quarts (U.S.) for auxiliary heater (Econoline models).

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TORQUE SPECIFICATION

Description	N·m (ft-lbs)	Description	N·m (ft-lbs)
Radiator to Body Sheet Metal E-150-E-350	14-20 (10-15)	Radiator Support to Frame Insulator Bolts — F-Super Duty Stripped Chassis	160-217 (118-160)
Radiator Hose Clamp Double Wire Clamp Bronco, F-150-F-350 and F-Super Duty, E-150-E-350	2.26-3.39 (20-30 in-lbs.)	Fan to Clutch, Fan/Clutch Assembly to Water Pump (All Engines Except 7.3L Diesel)	17-24 (12-18)
Radiator Hose Clamps Tangential Screw F-150-F-350, F-Super Duty and Bronco	2.8-3.9 (25-35 in-lbs.)	Shroud to Radiator — F-150-F-350, F-Super Duty and Bronco	7-10 (4-6)
Thermostat Housing 4.9L (300 CID) Six	17-20 (12-15)	Shroud to Radiator — F-Super Duty	21-32 (15-23)
Thermostat Housing V-8 Engines except 7.5L (460 CID)	17-24 (12-18)	Water Filter Hose Clip to Air Inlet Housing 3/8-16	28-33 (20-25)
Thermostat Housing 7.5L (460 CID)	32-37 (23-28)	Water Filter Hose Clip to Engine Idler Gear Cover 3/8-16	40-48 (29-36)
Radiator Top Brackets to Radiator Support F-150-F-350, F-Super Duty and Bronco	11-14 (8-11)	Transmission Oil Line Fitting to Radiator — F-150-F-350, F-Super Duty and Bronco	24-31 (18-23)
Radiator Top Brackets to Radiator Support — F-Super Duty Stripped Chassis	21-32 (15-23)	Transmission Oil Line Nut to Fitting on Radiator — F-150-F-350, F-Super Duty and Bronco	17-24 (12-18)
Fan/Clutch Assembly to Water Pump — 4.9L	41-136 (30-100)	Fan/Clutch Assembly to Water Pump — 7.3L Diesel	54-163 (40-120)
Radiator Support to Frame Insulator Bolts — F-150-F-350, F-Super Duty and Bronco	41-47 (30-35)		

COOLING SYSTEM PRESSURES (PSI)

	Operating Pressure	Min. Test Pressure
F-150-F-350, F-Super Duty, Bronco, E-150-E350	13	10

CQ1084-2Q

SPECIAL SERVICE TOOLS

Tool Number	Description
T83T-6312-A	Fan Clutch Pulley Holder — 6.9L Diesel
T83T-6312-B	Fan Clutch Nut Wrench — 6.9L Diesel
T84T-6312-C	Fan Clutch Pulley Holder — 4.9L Engine
T84T-6312-D	Fan Clutch Nut Wrench — 4.9L Engine
T85T-18539-AH	Heater Hose Disconnect Tool

CQ2135-1C

ROTUNDA EQUIPMENT

Model	Description
021-00012	Cooling System Pressurization Kit
021-00046	Anti-Freeze Tester

CQ1443-1L

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SECTION 27-04 Radiators

SUBJECT	PAGE
DESCRIPTION AND OPERATION	
Radiator	27-04-1
REMOVAL AND INSTALLATION	
Radiator and Fan Shroud	27-04-4
SERVICE PROCEDURES	
Aluminum Crossflow Radiators	27-04-17
Copper/Brass Radiators	27-04-16
SERVICE PROCEDURES (Cont'd.)	
Radiator Core Service	27-04-21
SPECIAL SERVICE TOOLS AND EQUIPMENT	27-04-24
SPECIFICATIONS	27-04-24
TESTING	27-04-4
VEHICLE APPLICATION	27-04-1

VEHICLE APPLICATION

All Light Truck Models.

DESCRIPTION AND OPERATION

WARNING: DO NOT STAND IN LINE OR NEAR RADIATOR FAN WHEN REVVING ENGINE.

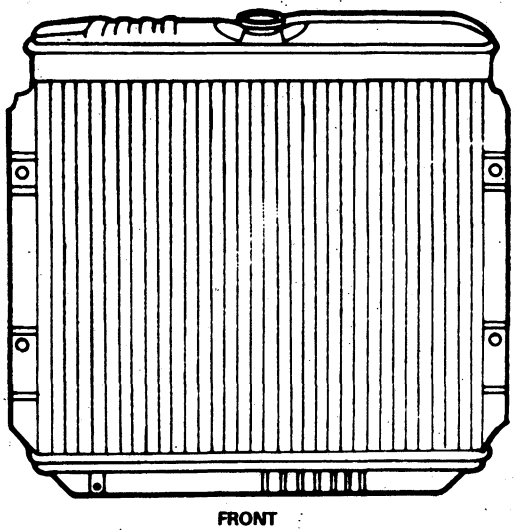
NOTE: When the cooling system is drained, fill with the approved coolant. Refer to Section 27-02, Cooling System Service.

Radiator

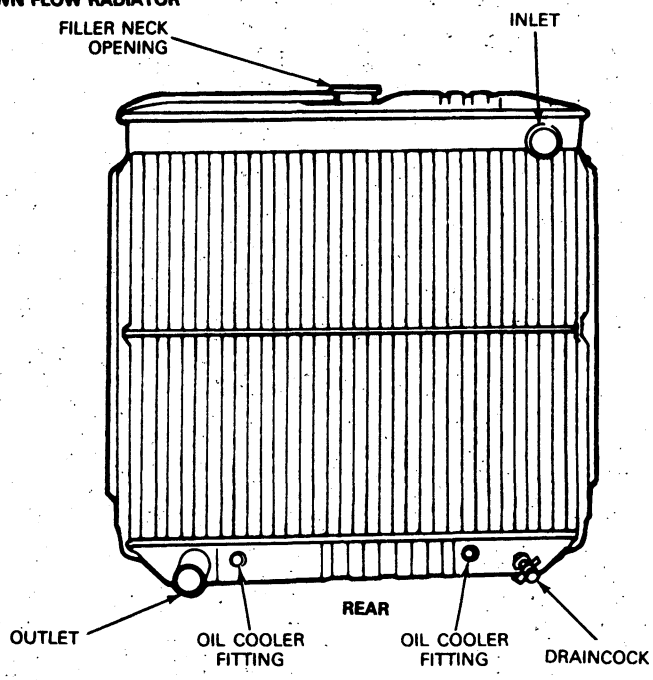
E-150—E-350—Gasoline Engines

All radiators are of the tube and fin type with the tubes arranged for vertical flow of the coolant. Two header tanks, one on the top and one on the bottom of the radiator provide uniform distribution of the coolant to the tubes. The radiator outlet port (lower tank) is connected to the water pump inlet port. The radiator inlet port (upper tank) is connected to the coolant outlet elbow of the engine, thereby permitting coolant circulation through the radiator when the thermostat is open.

TYPICAL DOWN FLOW RADIATOR



MANUAL TRANSMISSION



AUTOMATIC TRANSMISSION Q1517-2C

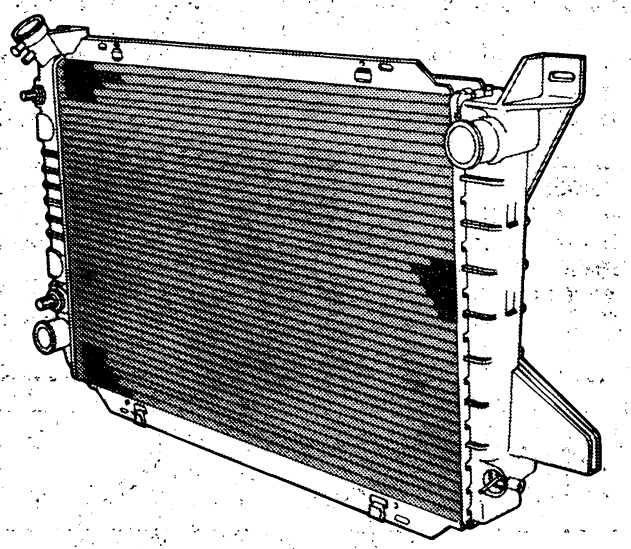
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DESCRIPTION AND OPERATION (Continued)

F-150—F-350, F-Super Duty Chassis Cab, Motor Home Chassis and Bronco—Gasoline Engines

All radiators are the tube and fin type with the tubes arranged for horizontal flow of the coolant. Two header tanks, one on each end of the radiator, allow uniform distribution of engine coolant to the radiator tubes. The radiator outlet port (lower hose connection) is connected by a hose to the water pump inlet port. The radiator inlet port (upper hose connection) is connected by the hose to the coolant outlet elbow of the engine, allowing coolant circulation through the radiator when the engine thermostat is open.

The crossflow radiator used with gasoline engines is constructed with a vacuum brazed aluminum core and nylon end tanks. The nylon end tanks are attached to the aluminum core by bending tabs on the core header over the edge of the nylon tank. An O-ring gasket is placed between the nylon tank and the radiator core header to achieve a seal between the tank and the radiator core header. The nylon tanks are a molded one-piece design with the mounting brackets part of each tank.



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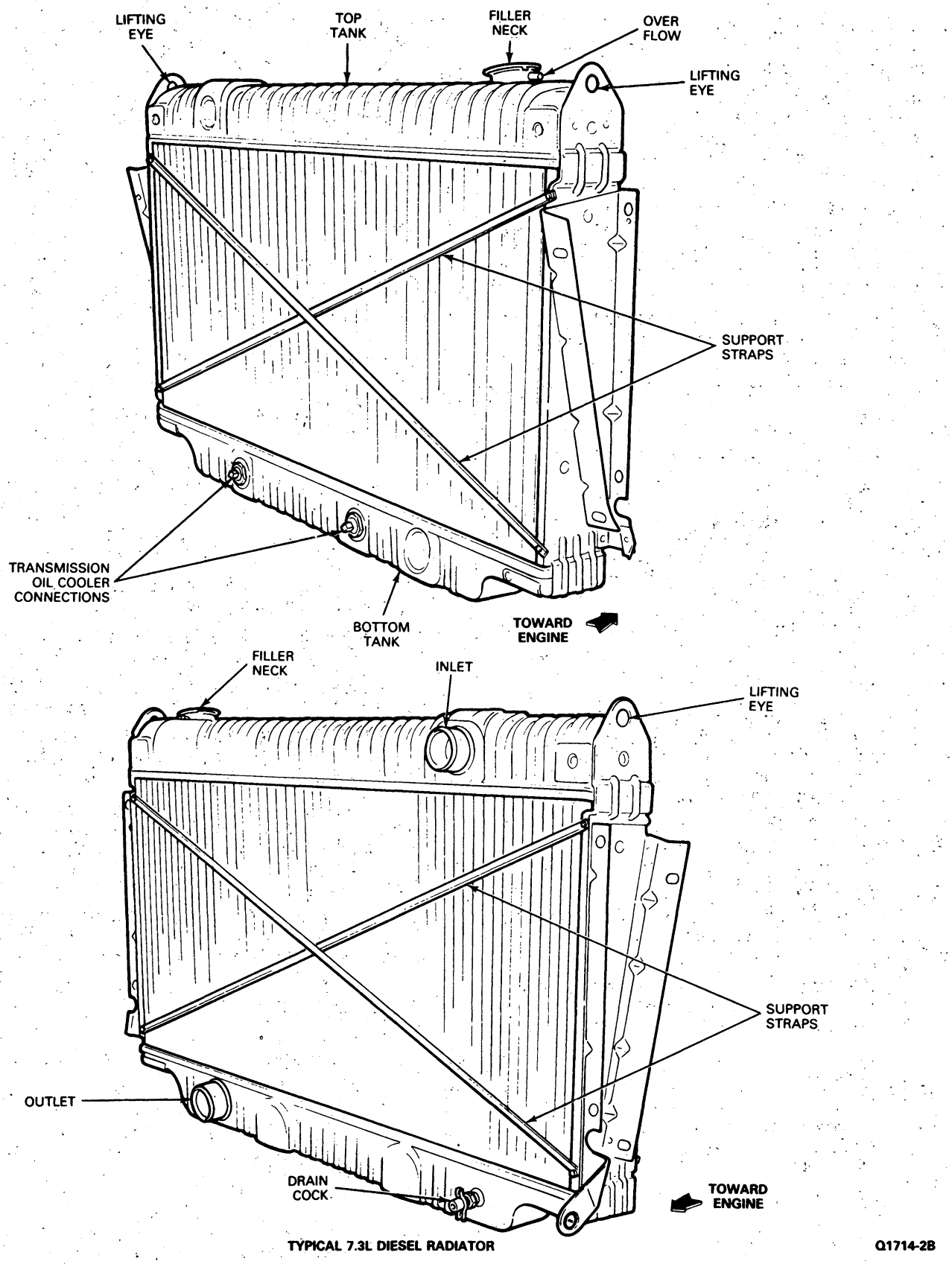
F-250—F-350, F-Super Duty Chassis Cab, Commerical Stripped Chassis and E-250—E-350—7.3L Diesel Engine

The vertical flow radiator used with the 7.3L diesel engine is the conventional copper/brass design similar to the E-Series gasoline engine radiators.

However, the diesel radiator uses turbulator type tubes and cannot be rodded out.

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DESCRIPTION AND OPERATION (Continued)



TYPICAL 7.3L DIESEL RADIATOR Q1714-2B

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TESTING

Leak Test

Clean the radiator before leak testing to prevent contaminating the test tank. Leak test the radiator in clean water at 145 kPa (21 psi) air pressure.

CAUTION: Do not leak test an aluminum radiator in the same water that is used to leak test copper/brass radiators. Flux and caustic cleaners may be present in the tank and they will attack aluminum.

A separate, clean test tank is recommended for aluminum radiators. If a separate tank is not available for aluminum radiator testing, thoroughly clean the test tank each time before testing an aluminum radiator.

NOTE: When a plastic tank is removed to service a tube-to-header leak, the core can be tested by clamping the tank to the core.

REMOVAL AND INSTALLATION

Radiator and Fan Shroud

E-150—E-350—All Engines

F-250—F-350, F-Super Duty Chassis Cab and Commerical Stripped Chassis with—7.3L Diesel Engine

Refer to the illustrations following Step 10 of Installation.

Removal

1. Drain the cooling system by removing the radiator cap and opening the drain cock located at the lower rear corner of the radiator tank. To prevent coolant loss when draining radiator, slip a hose on the draincock and drain coolant into a clean container.
2. Remove the rubber overflow tube from the coolant recovery bottle and detach it from the shroud (where appropriate).
3. Remove the shroud's two or four attaching bolts, lift the shroud back and drape it on the fan.
4. Loosen the upper and lower hose clamps at the radiator and remove the hoses from the radiator connectors.
5. Disconnect the two automatic transmission (if so equipped) oil cooling lines from radiator fittings.
6. Disconnect the heated water bypass hose attached to the lower tank (E40D equipped vehicles only).
7. Remove the four radiator attaching bolts.
8. Tilt the radiator back approximately 25mm (one inch) and lift directly upward, clear of the radiator support.
9. If either hose is to be replaced, loosen clamp at the engine end and slip the hose off the connection with a twisting motion.
10. Lift the shroud off the fan and remove from the vehicle.

Installation

1. Position shroud on fan until radiator is installed.
2. If either hose has been replaced install on engine and tighten clamps to 2.25-3.38 N·m (20-30 in-lbs).
3. Position radiator into engine compartment to radiator support, being careful to clear fan.
4. Install the radiator with four bolts and tighten to 14-20 N·m (10-15 ft-lbs).
5. Connect the two automatic transmission (if so equipped) oil cooling lines to radiator connectors.
6. Attach upper and lower radiator hoses and tighten clamps to 2.25-3.38 N·m (20-30 in-lbs).
7. Attach the heated water bypass hose (E40D equipped vehicles only).
8. Position shroud to radiator and attach with four bolts. Tighten bolts to 5.4-8 N·m (4-6 ft-lbs).
9. Attach rubber overflow tube from coolant recovery bottle to radiator (where applicable).

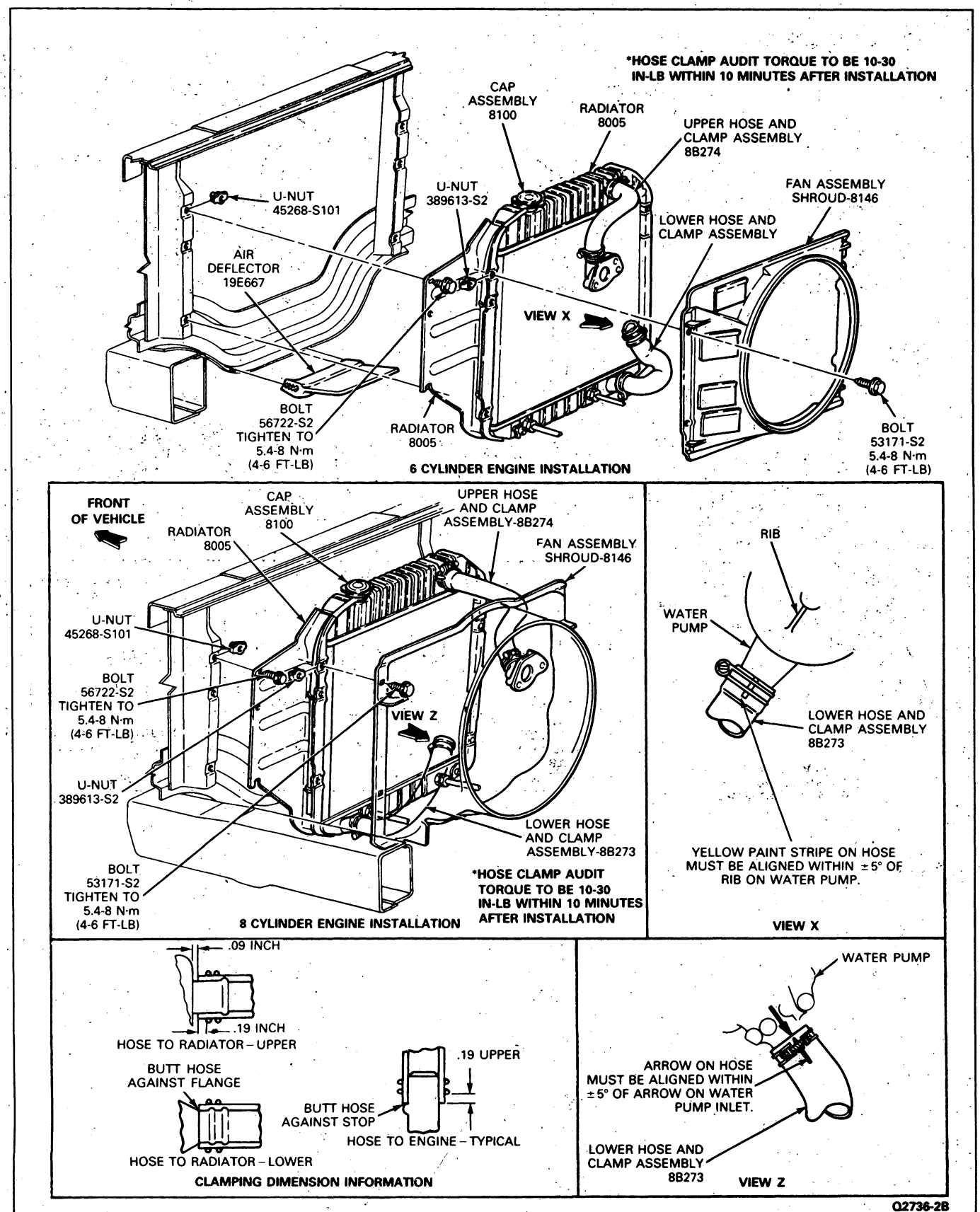
   WARNING: DO NOT STAND IN LINE WITH OR NEAR RADIATOR FAN WHEN ENGINE IS RUNNING.

NOTE: A coolant mixture of 50 percent coolant concentrate and 50 percent water is recommended to maintain best overall performance. To avoid damaging the radiator the coolant concentrate should not exceed 60 percent.

10. Install new 50/50 mixture of water and ethylene glycol and operate the engine for 15 minutes. Check the coolant level and bring it up to within 38mm (1-1/2 inches) of the radiator filler neck. Add two cooling system protection pellets. Part Number D9AZ-19558-A or equivalent.

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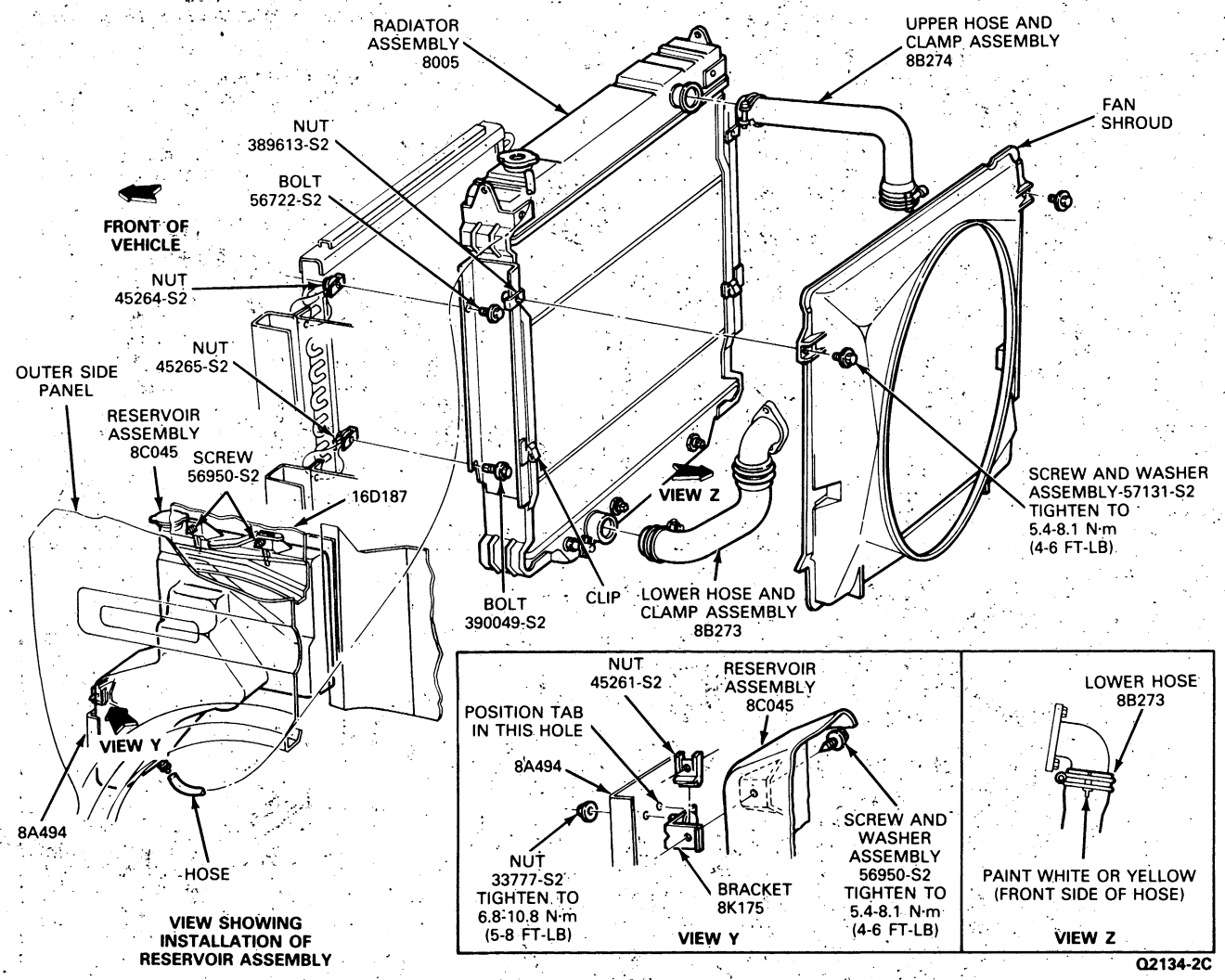
REMOVAL AND INSTALLATION (Continued)



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REMOVAL AND INSTALLATION (Continued)

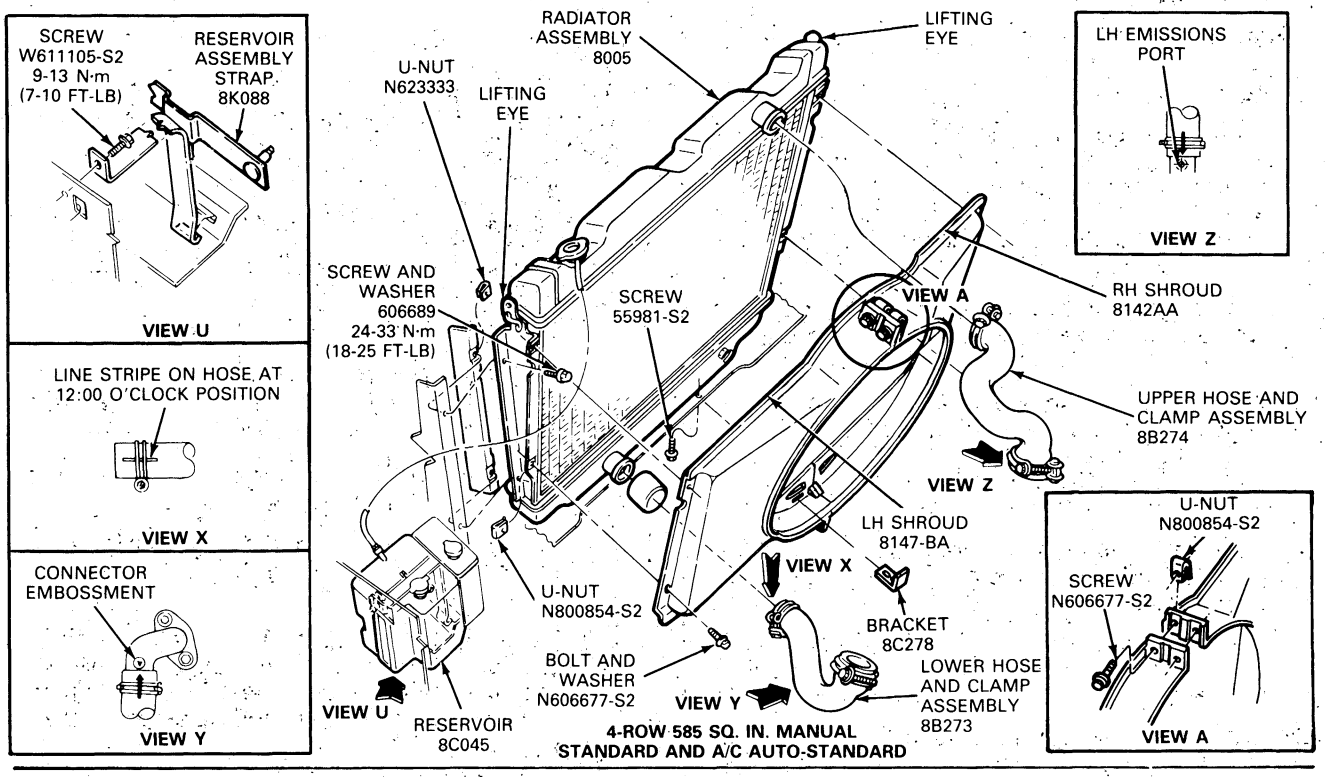
E-250—E-350 7.3L Diesel Engine

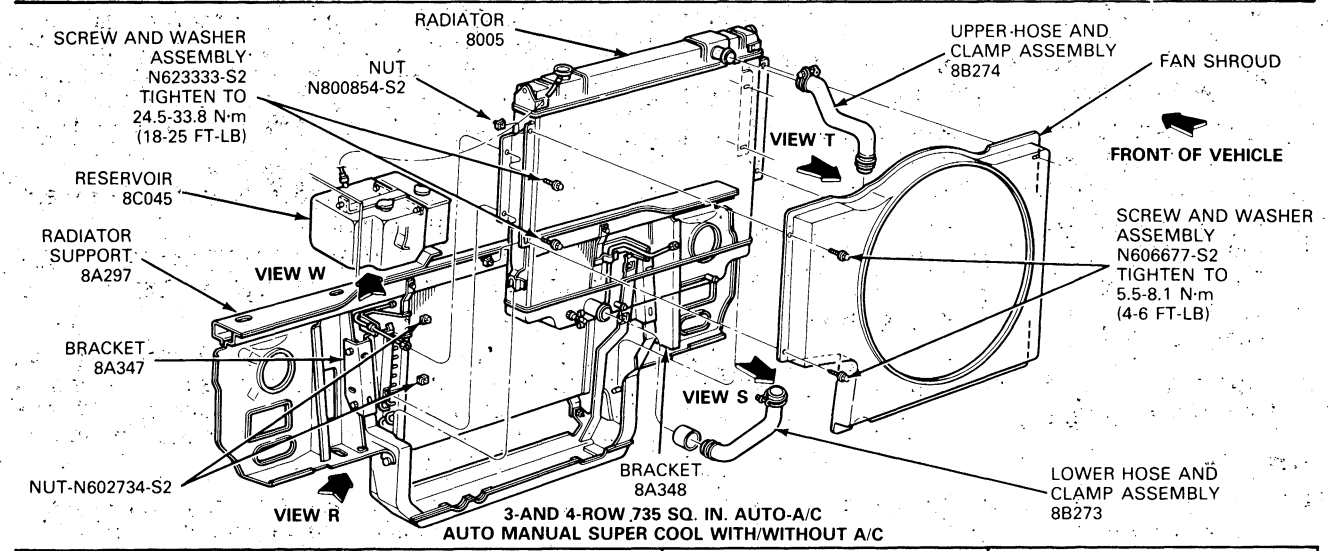


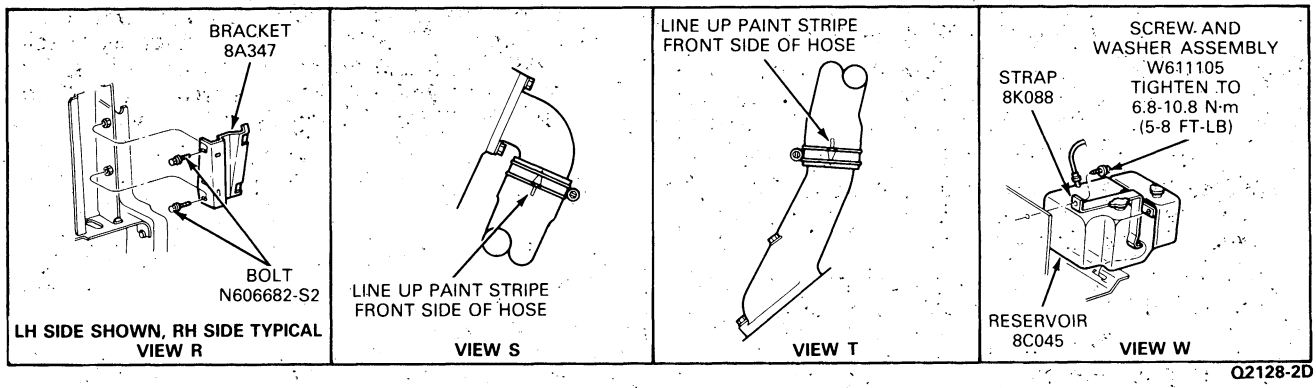
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REMOVAL AND INSTALLATION (Continued)

F-250—F-350 7.3L Diesel Engine







Q2128-2D

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REMOVAL AND INSTALLATION (Continued)

F-150—F-350, F-Super Duty Chassis Cab and Motor Home Chassis with Gasoline Engine

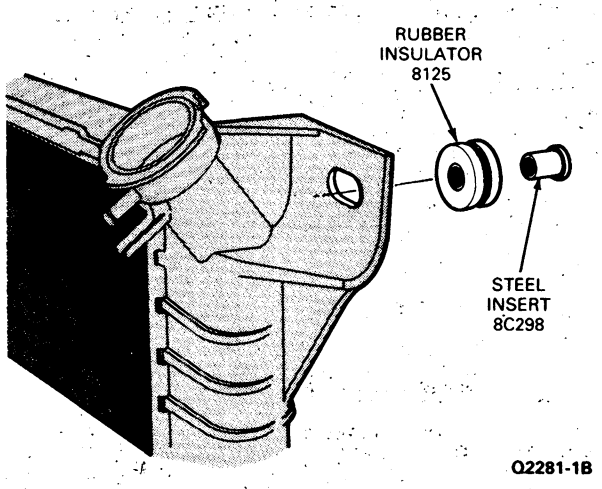
Refer to illustrations following Installation Step 12.

Removal

1. Drain the cooling system by removing the radiator cap and opening the draincock located at the lower rear corner of the radiator tank. To prevent coolant loss when draining radiator, slip a hose on the draincock and drain coolant into a clean container.
2. Remove the rubber overflow tube from the coolant recovery bottle and detach it from the radiator.
3. Remove the shroud's two upper attaching screws, lift the shroud out of the lower retainer clips and drape it on the fan. On F-Super Duty Motor Home Chassis vehicles remove the 2 screws at the bottom of the shroud.
4. Loosen the upper and lower hose clamps at the radiator and remove the hoses from the radiator connectors.
5. Remove the heated water bypass hose (E4OD equipped vehicles only), located directly below the overflow nipple on the radiator outlet tank.
6. Disconnect the two automatic transmission (if so equipped) oil cooling lines from radiator fittings.
7. Remove the two radiator upper attaching screws or bolts.
8. Tilt the radiator back approximately 25mm (one inch) and lift directly upward, clear of the radiator support and cooling fan.
9. If either hose is to be replaced, loosen clamp at the engine end and slip the hose off the connection with a twisting motion.
10. Lift the shroud off the fan and remove from the vehicle.
11. Remove the radiator lower support rubber pads (insulators).

Installation

1. Position the radiator lower support rubber pads to the lower frame.
2. Position shroud on fan until radiator is installed.
3. If either hose has been replaced, install on engine with index arrow in line with mark on fitting on engine. Tighten clamps to 2.25-3.38 N·m (20-30 in-lbs).
4. Install the heated water bypass hose (E4OD equipped vehicles only), to the nipple located below the overflow tank.
5. Position radiator into engine compartment to radiator support, being careful to clear fan.
6. Inspect the radiator upper rubber insulators. Replace if necessary.



7. Install two upper attaching bolts or screws. Tighten to 11-14 N·m (8-11 ft-lb).
8. Connect the two automatic transmission (if so equipped) oil cooling lines to radiator connectors.
9. Attach radiator upper and lower hoses to radiator. Position hose on radiator connection so that index arrow on hose is in line with mark on connection. Tighten hose clamps to 2.25-3.38 N·m (20-30 in-lb).
10. Position shroud on the lower retainer clips and attach the top of the shroud to radiator with two screw and washer assemblies. On F-Super Duty Motor Home Chassis vehicles install the 2 lower screws. Tighten screws to 5.5-8 N·m (4-6 ft-lbs).
11. Attach rubber overflow tube from coolant recovery bottle to radiator.

WARNING: DO NOT STAND IN LINE WITH OR NEAR RADIATOR FAN WHEN ENGINE IS RUNNING.

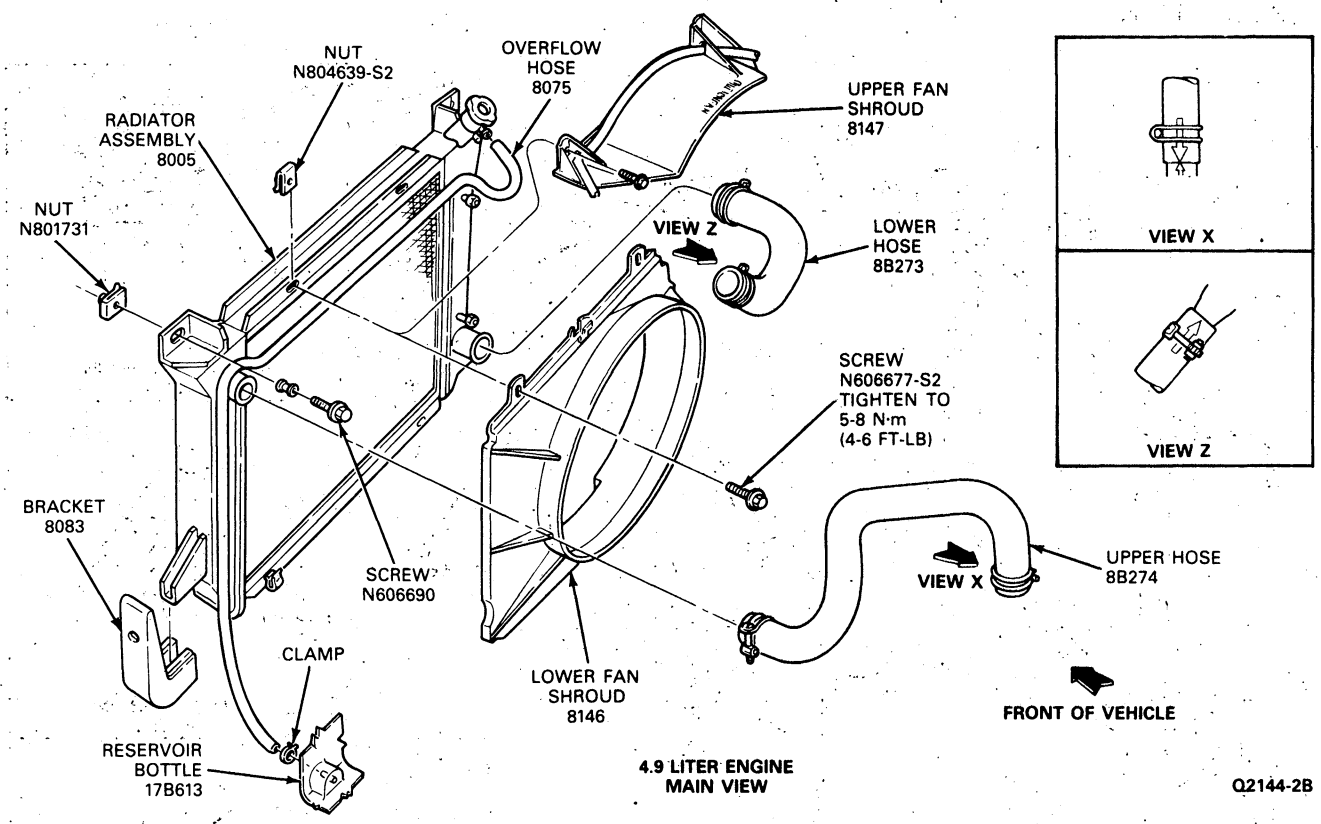
NOTE: A coolant mixture of 50 percent coolant concentrate and 50 percent water is recommended to maintain best overall performance. To avoid damaging the radiator, the coolant concentrate should not exceed 60 percent.

12. Install new 50/50 mixture of water and ethylene glycol and operate the engine for 15 minutes. Check the coolant level and bring it up to within 38mm (1-1/2 inches) of the radiator filler neck. Add two cooling system protection pellets, Part Number D9AZ-19558-A or equivalent. Refer to Section 27-02, Cooling System Service.

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REMOVAL AND INSTALLATION (Continued)

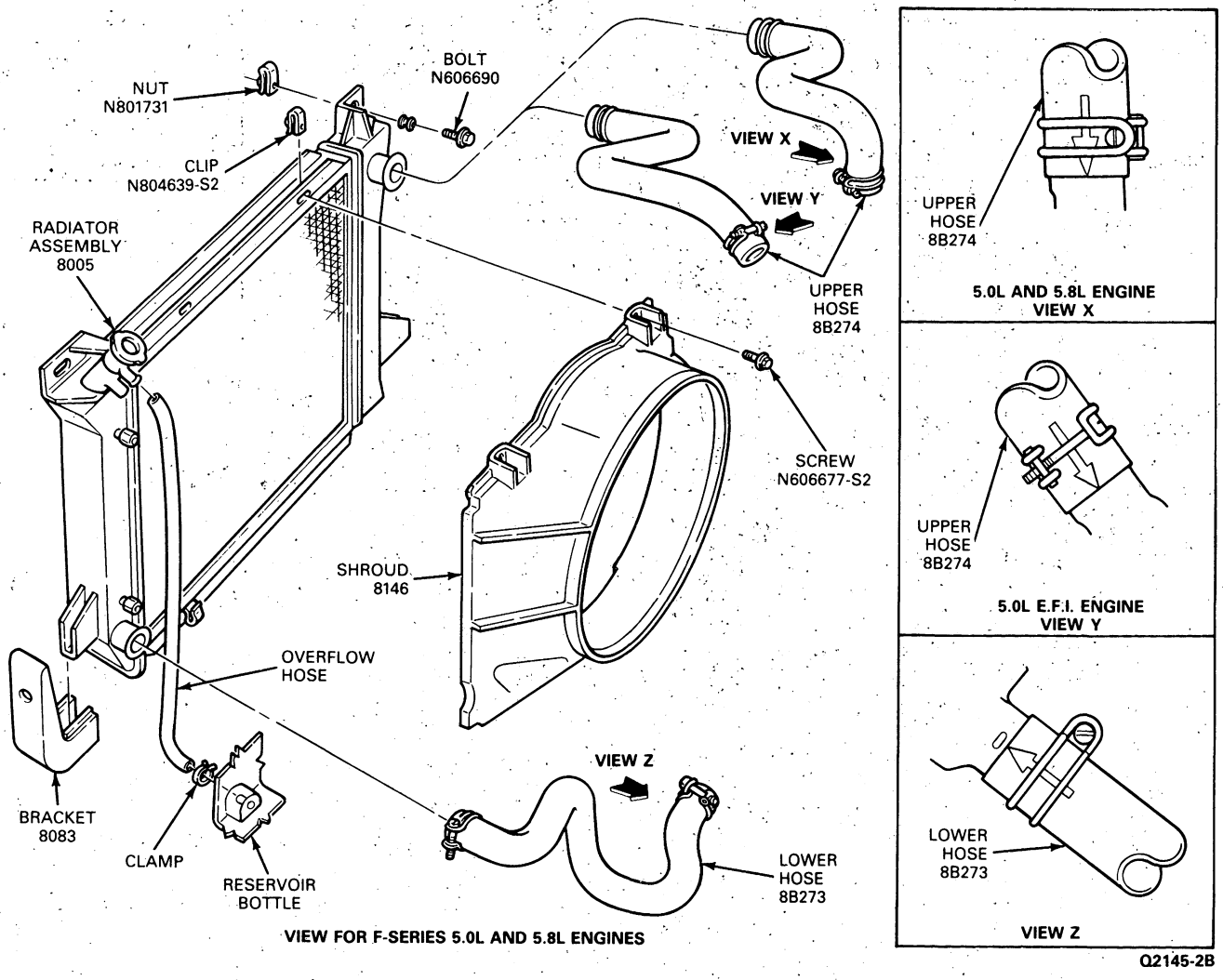
F-150—F-350, Bronco—4.9 (300 CID) Engine



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REMOVAL AND INSTALLATION (Continued)

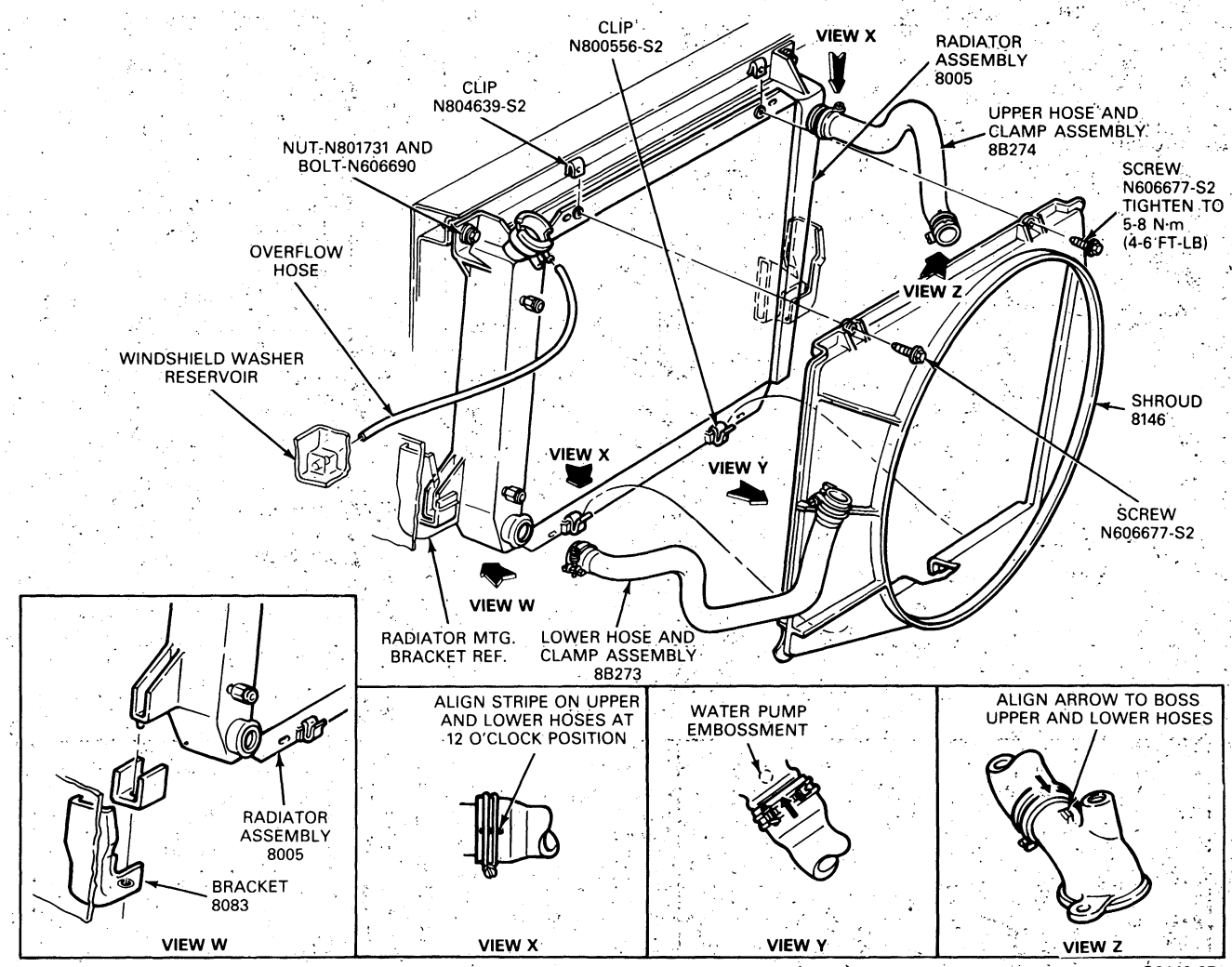
F-150—F-350, Bronco—5.0L (302 CID), 5.8L (351 CID) Engines



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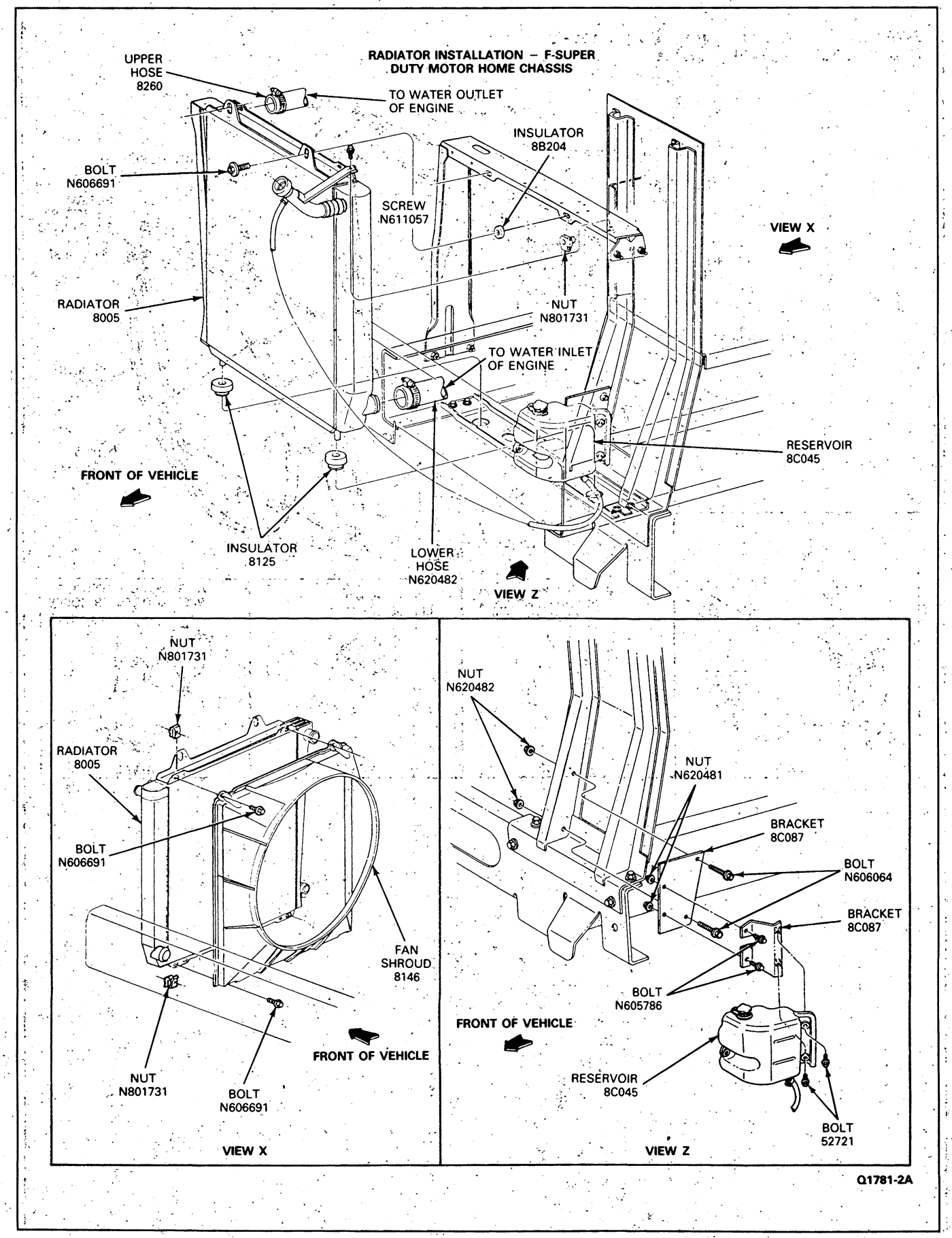
REMOVAL AND INSTALLATION (Continued)

F-250 HD—F-350 and F-Super Duty Chassis Cab with 7.5L (460 CID) Engine



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REMOVAL AND INSTALLATION (Continued)



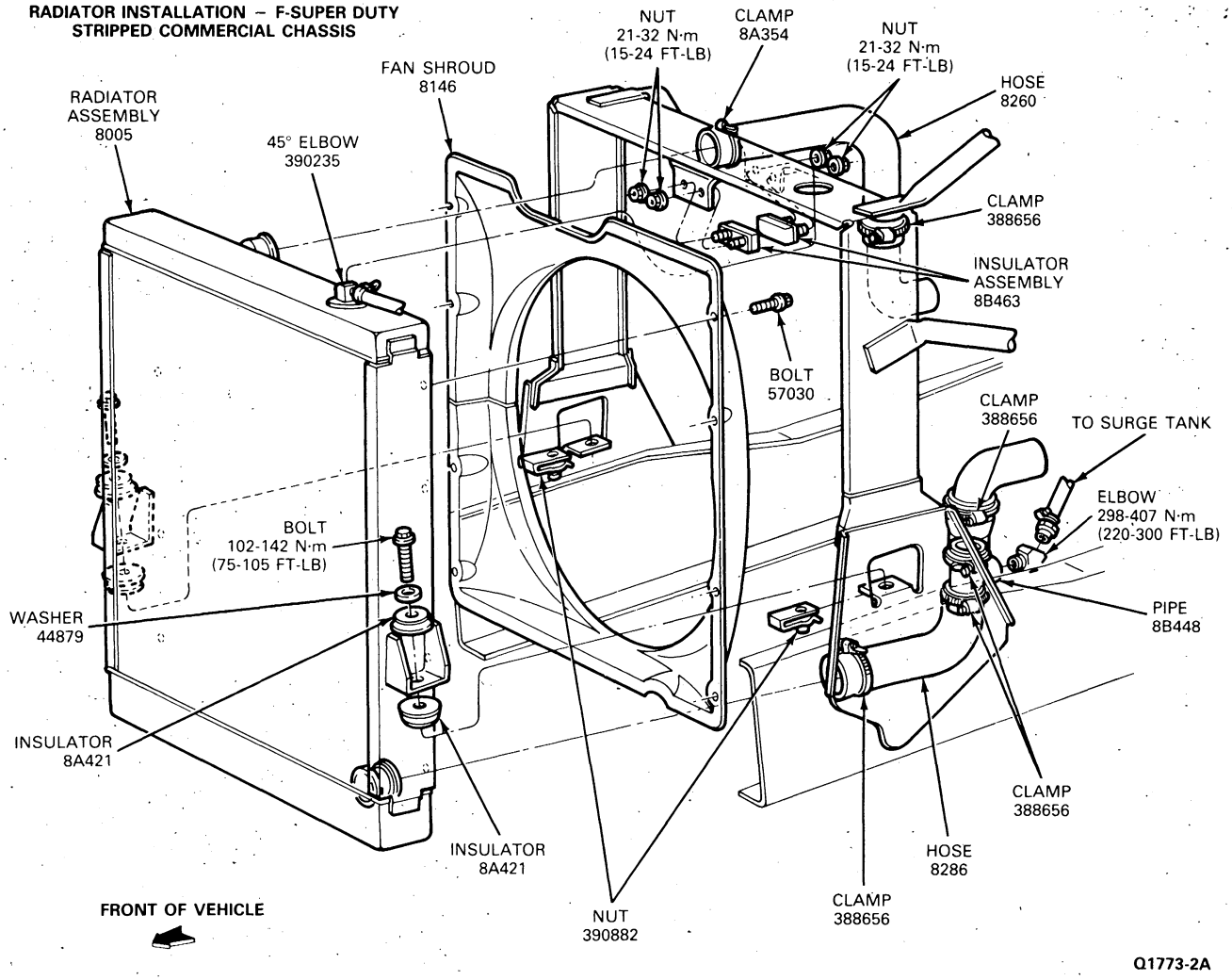
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REMOVAL AND INSTALLATION (Continued)

Radiator and Fan Shroud—F-Super Duty Commerical Stripped Chassis

Removal

1. Drain the radiator by removing the radiator cap and disconnecting the lower radiator hose. To prevent coolent loss when drainingthe radiator, drain the radiator into a clean container.
2. Remove the rubber overflow tube from the coolent recovery reservoir.
3. Remove the fan shrouds eight attaching bolts, lift the shroud back and drape it over the fan.
4. Loosen the upper radiator hose clamp, and remove the hose from the radiator.
5. Remove the two radiator attaching bolts from the side mounts, and remove the rubber insulators from the mounting pads.
6. Remove the upper radiator support by removing four attaching bolts, and remove the radiator by lifting up and out.
7. Lift the fan shroud off the fan and remove from the vehicle.



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REMOVAL AND INSTALLATION (Continued)

Installation

1. Position the fan shroud on the fan.
2. Install the radiator from the bottom into the upper radiator insulators, then install the rubber insulators and the mounting bolts. Tighten the bolts to 102-142 N·m (75-105 ft-lb).
3. Install the upper and lower hoses and tighten the hose clamps.
4. Install the fan shroud and tighten the eight shroud bolts.
5. Install the overflow hose to the coolent recovery bottle.

WARNING: DO NOT STAND IN LINE WITH OR NEAR THE RADIATOR FAN WHEN THE ENGINE IS RUNNING.

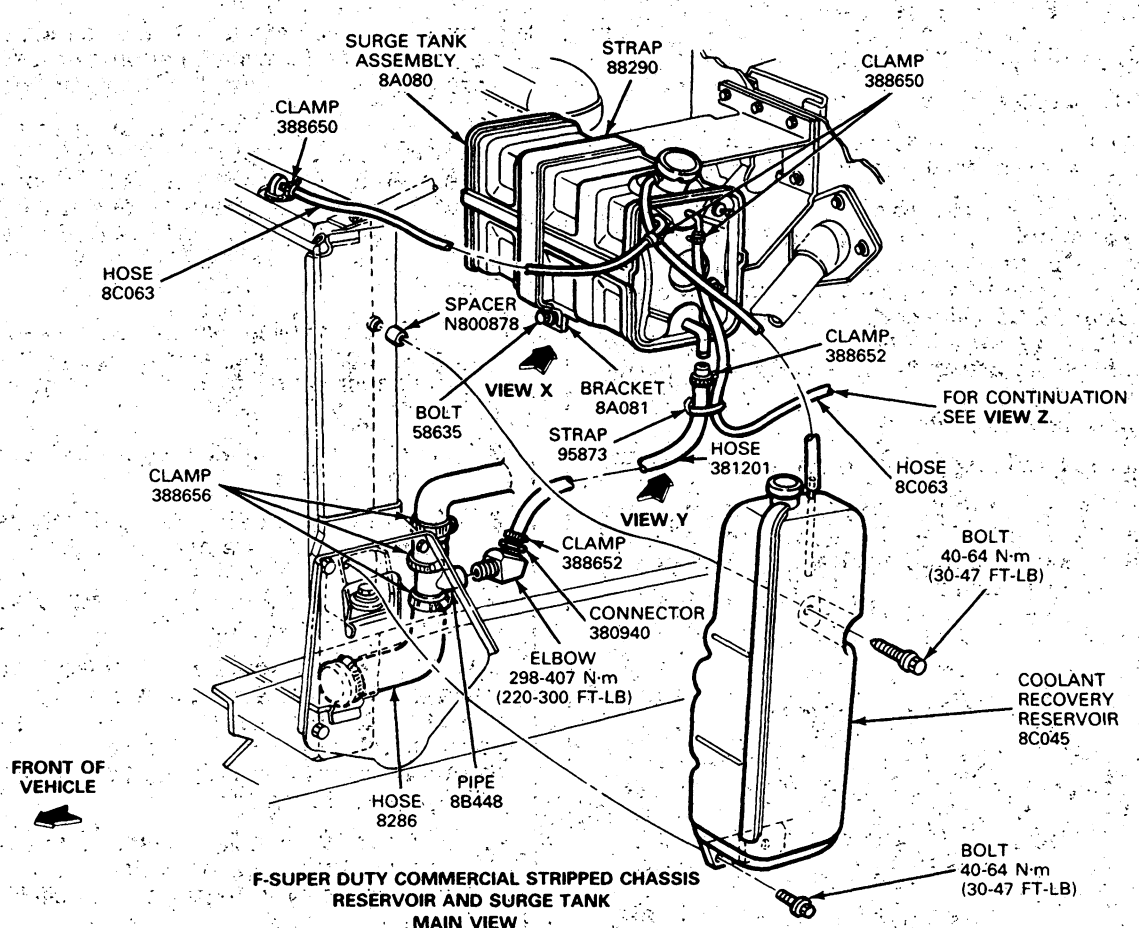
NOTE: A coolent mixture of 50 percent coolent concentrate and 50 percent water is recommended to maintain best overall performance. To avoid damaging the radiator the coolent coccentrate should not exceed 60 percent.

6. Install new 50/50 mixture of water and ethylene glycol and operate the engine for 15 minutes. Check the coolent level and bring it up to within 38mm (1-1/2 inches) of the radiator filler neck. Add two cooling system protection pellets. Part Number D9AZ-19558-A or equivalent.

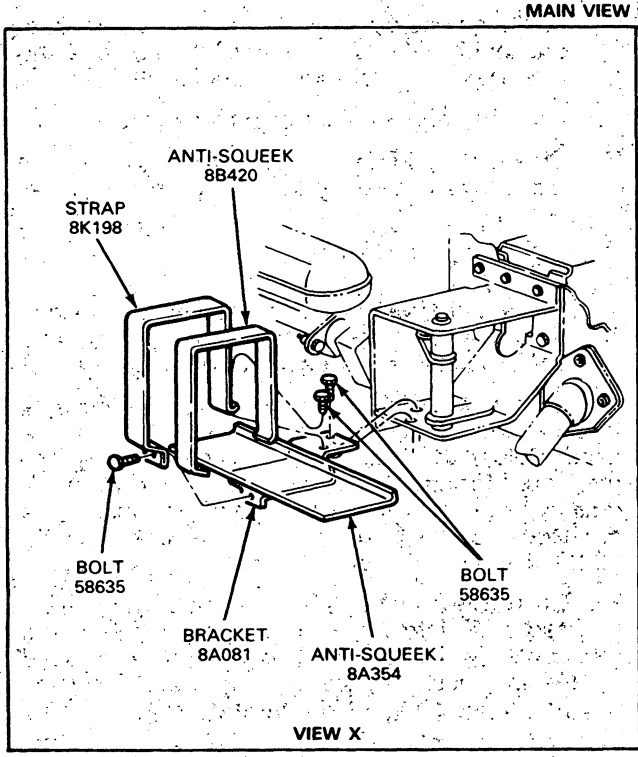
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REMOVAL AND INSTALLATION (Continued)

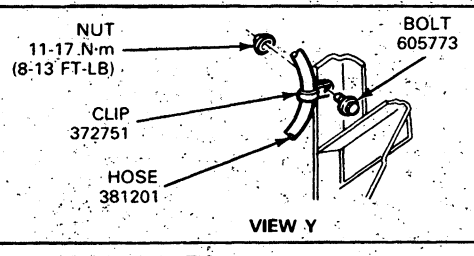
F-Super Duty Commerical Stripped Chassis— Reservoir and Surge Tank



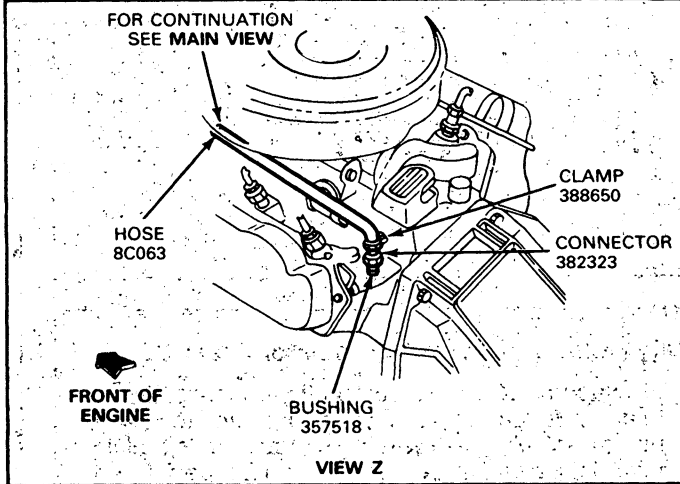
F-SUPER DUTY COMMERCIAL STRIPPED CHASSIS RESERVOIR AND SURGE TANK MAIN VIEW



VIEW X



VIEW Y



VIEW Z

Q1774-2B

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SERVICE PROCEDURES

Copper/Brass Radiators

E-150—E-350 All Engines

F-250—F-450 7.3L Diesel Engine

Radiator Core and Tank Service

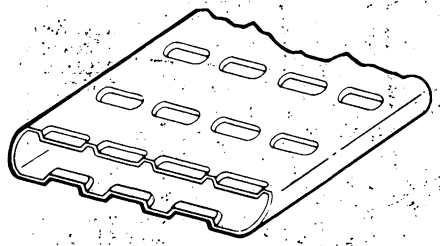
Conventional soft solder service methods should be used when repairing the copper/brass core.

CAUTION: Only manufactured or natural gas torches should be used to perform radiator repairs. Do not use acetylene. No attempt should be made to repair a fractured radiator tank. It must be replaced. Tank repairs usually result in repeated failures due to flexing of the tank caused by pressure increase and decrease.

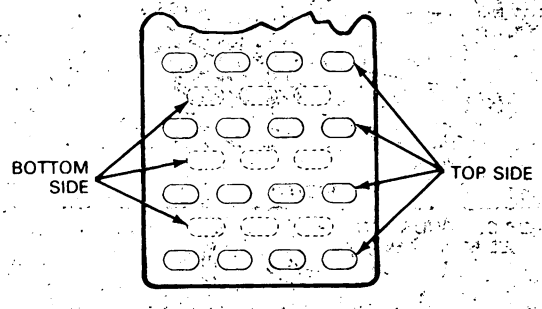
Cleaning and Inspection

Refer to Section 27-02, Cooling System Service.

CAUTION: Do not rod out the copper/brass diesel radiator. The tubes have integral turbulators embossed into them and damage to the tubes will result.



SECTIONAL VIEW



VIEW SHOWING POSITIONS OF TURBULATORS ON BOTH SIDES OF TUBE

Q2168-1A

Oil Cooler and Soldered Radiator Drain Cock

Replacement of the automatic transmission oil cooler or radiator draincock in the radiator lower tank is usually performed by radiator specialty shops. However, the operation can be performed, providing proper equipment is available.

The draincock is soldered directly to the radiator lower tank.

Only manufactured or natural gas torches should be used to perform radiator repairs. Do not use acetylene.

No attempt should be made to repair a fractured radiator tank. Should a fractured tank be encountered, it must be replaced. Tank repairs usually result in repeat failures, due to the flexing of the tank caused by pressure increase and decrease.

Removal

1. Drain the cooling system. To prevent coolant loss when draining radiator, slip a hose on the draincock and drain coolant into a clean container.
2. Remove the radiator from the vehicle as outlined.
3. Thoroughly clean the radiator assembly internally and externally by submerging in a tank filled with a caustic solution. Then, using clean water, flush until the caustic solution is removed from all internal and external surfaces.

CAUTION: Care should be exercised during the disassembly and assembly solder operation of radiator components. Avoid excess heat concentration which could result in burning through the radiator sheet metal or loosening an adjoining soldered area.

4. Remove the radiator tank containing the damaged or leaking oil cooler. (Tank removal is not necessary for repair of draincock).
5. Melt the puddled solder from the oil cooler inlet and outlet fittings, or draincock. Remove the retaining rings from the oil cooler fittings.
6. Remove the oil cooler or draincock.
7. Clean the soldered surface areas and inspect and tin as necessary to ensure proper solder bonding.

Installation

1. **Draincock:** Position the replacement draincock or draincock boss in the tank opening and solder using the procedures for oil cooler.

NOTE: If one-piece draincock is not available, a threaded boss (8120) and draincock (8115) must be used. Solder the boss into the tank following the procedure for one-piece draincocks, then wrap the draincock threads with sealer tape and install the draincock in the boss. Tighten the draincock to 16-20 N·m (12-15 ft-lbs).

Oil Cooler: Install the replacement oil cooler assembly into the tank openings and secure cooler with new retaining rings. For bead design, push ring past fitting bead. Retaining ring tangs should point away from tank.

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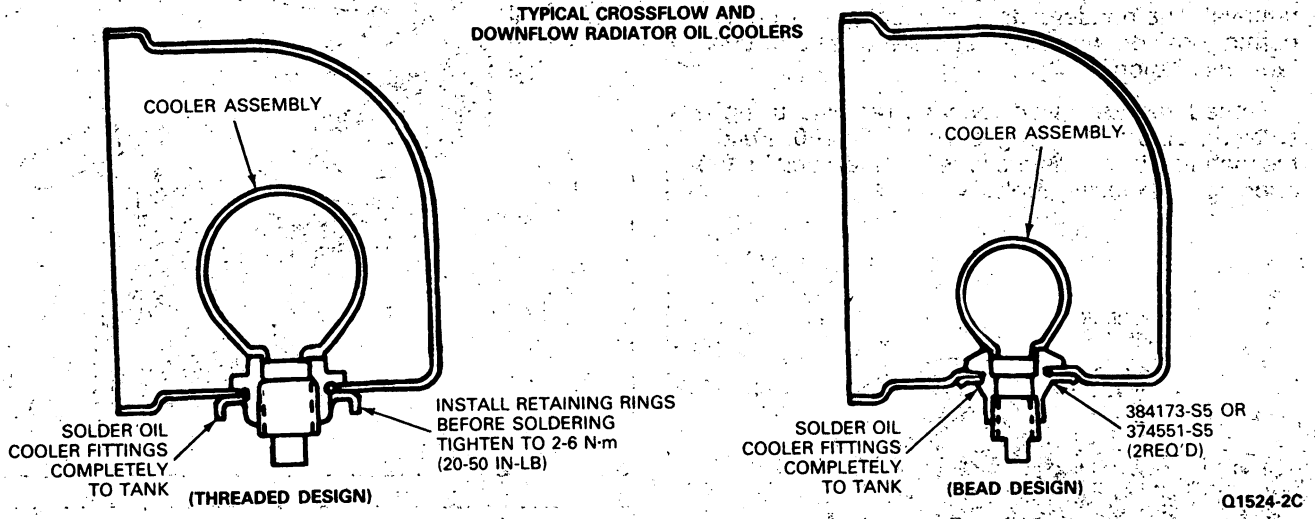
SERVICE PROCEDURES (Continued)

2. Puddle-solder the oil cooler fitting completely to the tank.
3. Seat the tank assembly in the header well and solder securely, completely filling the well. Use 40-60 solder with either zinc chloride 30 (BAUME) or 5-B NALCO flux.
4. Flush off all excess acid, internally and externally.
5. Pressure test the radiator assembly to 132-144 kPa (19-20 psi) for leaks.
6. Paint as required.
7. Install the radiator and fan shroud in the vehicle as outlined.

NOTE: A mixture of 50 percent coolant concentrate and 50 percent water is recommended to maintain best overall performance. To avoid damaging the radiator, the coolant concentrate should not exceed 60 percent.

8. Flush the cooling system and refill and bleed with the recommended mixture of all-season coolant. Refer to Section 27-02, Cooling System Service.

TYPICAL CROSSFLOW AND DOWNFLOW RADIATOR OIL COOLERS



Threaded Radiator Draincock

Repair or Replace

1. Drain the cooling system and remove the threaded draincock assembly from the radiator.
2. Inspect the pipe threads on the draincock assembly and the threaded draincock boss in the radiator tank.
3. If the boss threads are damaged, repair them with a 1/4 inch pipe tap. If the threads are damaged beyond repair, install a new draincock boss in the radiator tank.
4. Apply a small amount of D8AZ-19554-A Pipe Sealant with TEFLON® or equivalent to threads and install the draincock. Tighten the draincock to 16-20 N·m (12-15 ft-lbs).
5. Fill and bleed the cooling system and check for leaks. Refer to Section 27-02, Cooling System Service.

Aluminum Crossflow Radiators

F-150—F-Super Duty, Bronco—Gasoline Engines

CLEANING

External

The aluminum core can be cleaned externally with a soft bristle brush, warm water and a mild household liquid detergent. Then, rinse with clear water.

If the radiator is equipped with an oil cooler, install steel or brass plugs in the oil cooler fittings before cleaning and keep them installed during the entire service operation.

Internal

NOTE: Do not use caustic cleaning solutions or copper/brass radiator cleaning agents on aluminum radiators. Internal cleaning of the aluminum tubes can be accomplished with sonic cleaning equipment, or, by removing one end tank to gain access to tubes. Then, clean the tubes with a mild household liquid detergent. Rinse the core with clean water when completed. Do not use a metal brush to clean an aluminum core. Use only horsehair, bristle or nylon brushes.

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SERVICE PROCEDURES (Continued)

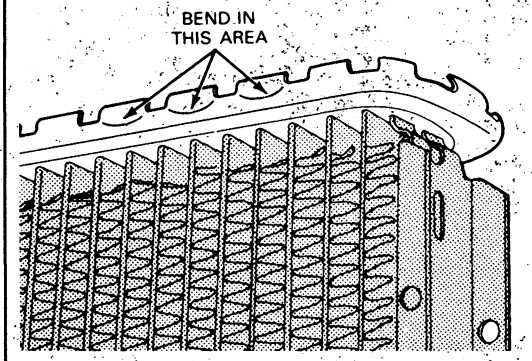
Radiator Tank

Removal

The radiator tanks are molded, glass-filled nylon and are attached to the core header by bending the header tabs over the edge of the tank.

When removing a nylon tank, a screwdriver or one of the various special tools available can be used to open the header tabs. Some of these tools, including a screwdriver, may cause a small section of the header side to bend with the tabs as they are opened. This slight deformation is permissible, provided the tabs are opened only enough to tank removal. The header sides will usually return to the normal position when the tabs are crimped during tank installation.

Procedures are given for tank removal using a screwdriver or a Borroughs Tool BT-8260. Follow the manufacturer's instructions for other radiator tab opening and closing tools.



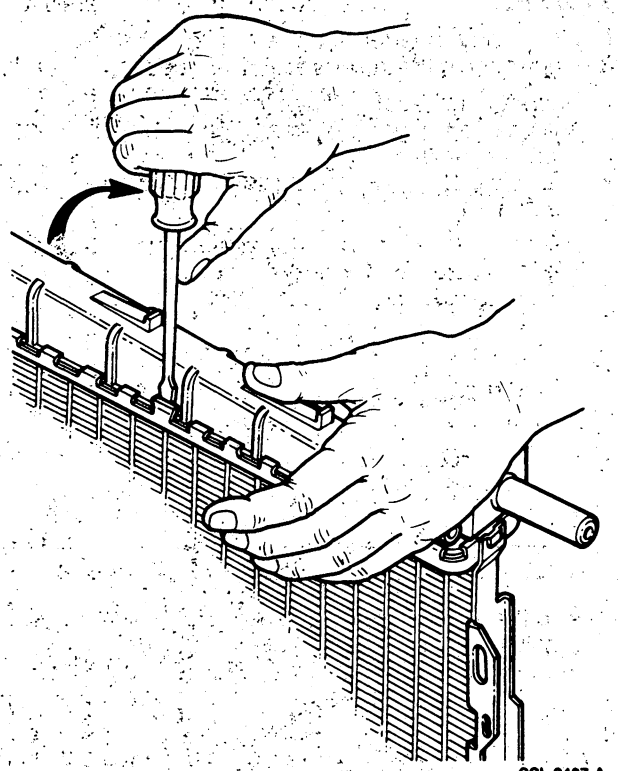
Q2171-1A

With Screwdriver

1. Insert the end of a medium tip screwdriver between the end of the header tab and the tank. Then, press the screwdriver blade against the tank to bend (pry) the tab away from the tank edge. Repeat this procedure for each tab.

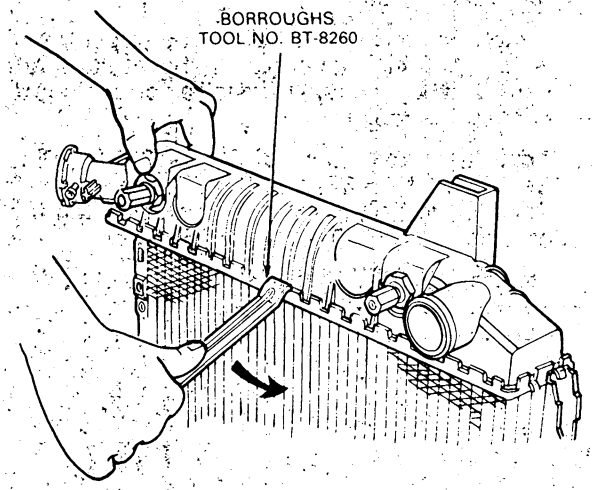
NOTE: Bend (open) the tabs only enough for tank removal.

2. Lift the tank from the core header when all of the header tabs are bent away from the tank edge.
3. Remove the O-ring gasket from the header.


CCL 2407-A

With Borroughs Tool BT-8260

1. Insert the end of Borroughs Tool BT-8260 between the end of the header tab and the tank. Then, push the tool handle down toward the core to bend the tab away from the radiator tank. **Do not open the tabs more than is necessary for tank removal.**
2. Repeat Step 1 for each header tab. Then, lift the tank from the header.
3. Remove the O-ring gasket from the header.



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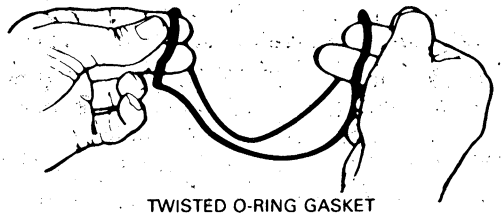
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SERVICE PROCEDURES (Continued)

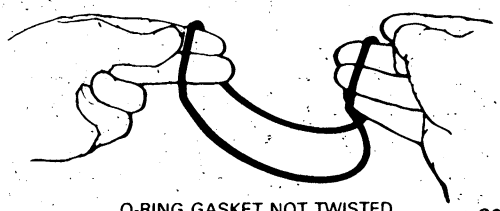
Installation

NOTE: If any header tabs are missing from an aluminum core, the core should be replaced.

1. Inspect the seal surface of the radiator core header to ensure it is clean and free of foreign material or damage.
2. Check the new O-ring to ensure it is not twisted.



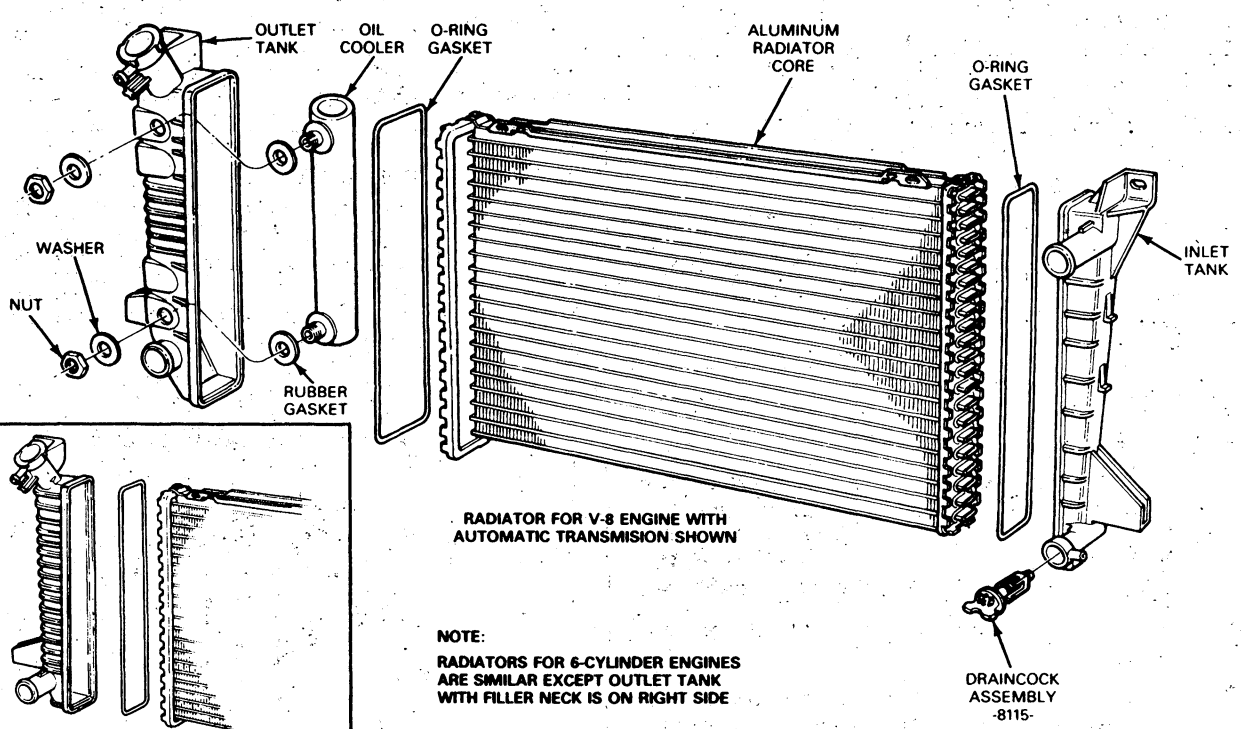
TWISTED O-RING GASKET



O-RING GASKET NOT TWISTED

Q2170-1A

3. Dip the new O-ring gasket in glycol or silicone or equivalent lubricant, and place the gasket in the header groove.
4. If the outlet tank is being replaced and is equipped with an oil cooler transfer the oil cooler from the replaced tank to the new tank as outlined.



RADIATOR FOR V-8 ENGINE WITH AUTOMATIC TRANSMISION SHOWN

OUTLET TANK FOR V-8 ENGINE WITH STANDARD TRANSMISSION

NOTE:

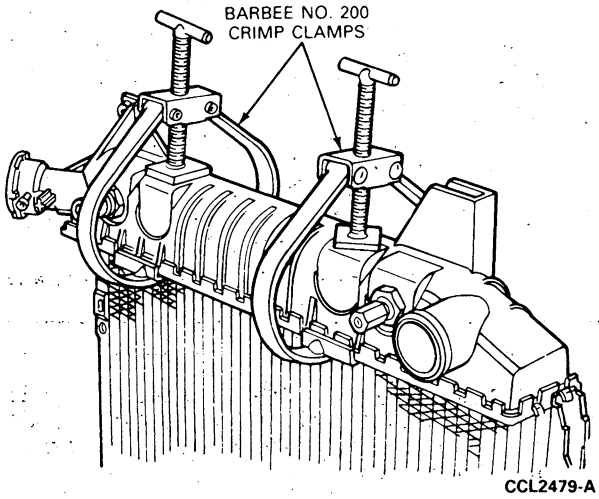
RADIATORS FOR 6-CYLINDER ENGINES ARE SIMILAR EXCEPT OUTLET TANK WITH FILLER NECK IS ON RIGHT SIDE

CCL 2408-A

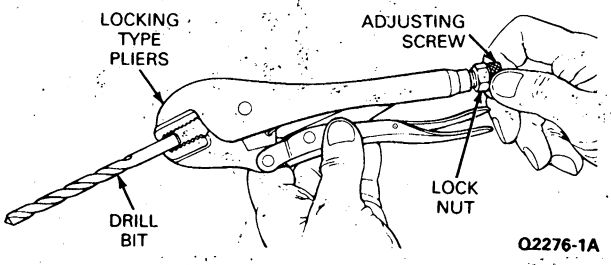
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SERVICE PROCEDURES (Continued)

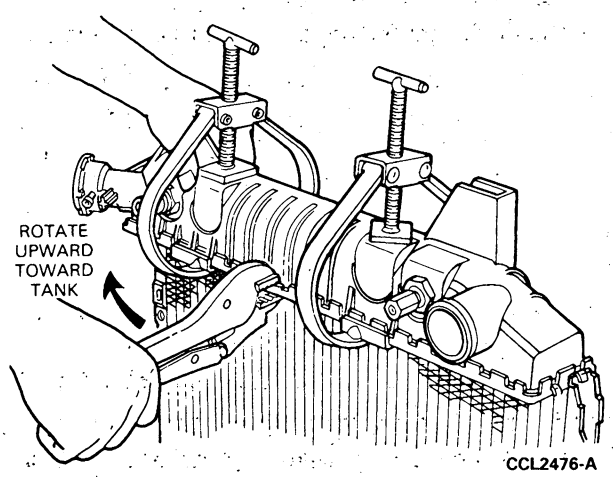
5. Position the tank to the header using care not to scratch the tank sealing surfaces with the header tabs. Be sure the top and bottom of the tank is position properly with the other tank.
6. Clamp the tank in position on the header with two header clamps as shown. Tighten the header clamps to compress the O-ring gasket.



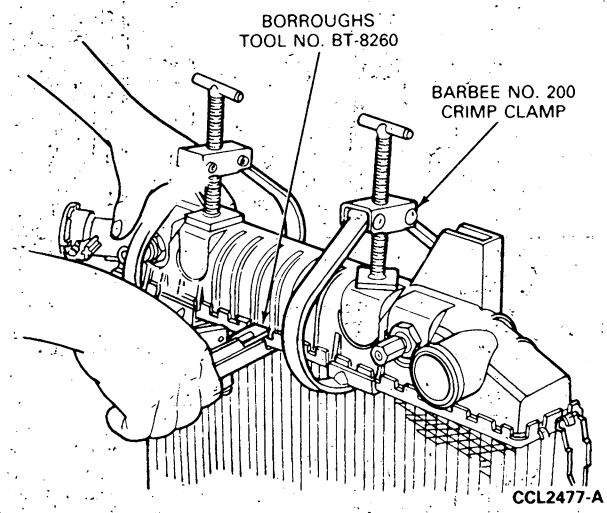
7. If locking-type pliers are used to squeeze the header tabs against the tank, install a hex nut on the pliers adjusting screw.
8. With the jaws of the locking-type pliers closed and locked, turn the adjusting screw to position the jaws against the shank of a 13/32-inch drill bit. Then, tighten the hex nut on the adjusting screw against the handle to lock the adjustment in place.



9. Squeeze the header tabs down against the lip of the tank base with the locking-type pliers while rotating the pliers toward the tank.



10. If a special crimping tool is used follow the manufacturer's instructions.

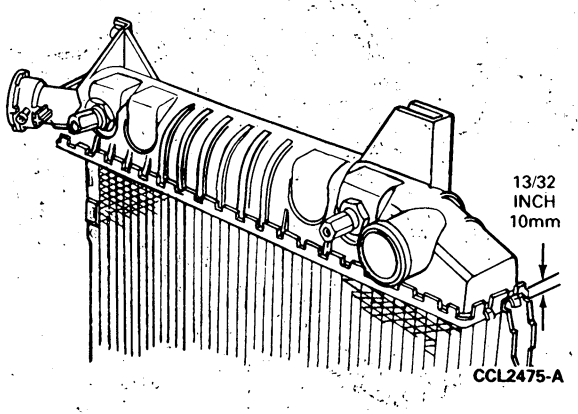


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SERVICE PROCEDURES (Continued)

NOTE: It is, however, important that the assembled height of the crimp be 10.3mm (13/32 inch) when measured from the bottom of the header to the top of the tab.

11. Remove the header clamps and squeeze the header tabs down that were behind the clamps.
12. Leak test the radiator at 145 kPa (21 psi). Most minor leaks at the header-to-tank seal can be corrected by again squeezing the header tabs down against the tank lip in the area of the indicated leak.



Radiator Core Service

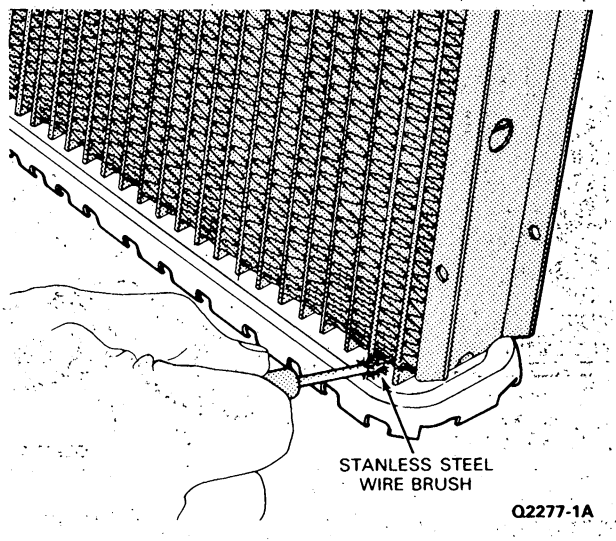
The only approved service method for the aluminum radiator core is using a two-part epoxy material. The materials and supplies necessary to service the aluminum core radiator are:

- EPOXI-PATCH KIT No. 6C Aluminum, Hysol Division of the Dexter Corporation, Olean, New York 14760.
- Sandpaper and/or emery paper—80 or 100 grit.
- Stainless steel wire brush No. 23151 or equivalent, Milwaukee Brush Manufacturing Co., Menomonee Falls, Wisconsin 53051.
- 375-watt heating lamp.
- Mixing card and spatulas.

Service Procedure

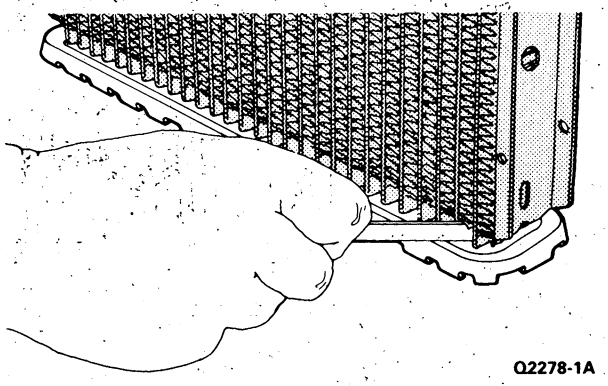
1. Clean and leak test core as outlined.
2. Mark leak(s) and dry core with compressed air in area of leak(s).
3. If leak is in fin area of core, spread fins away from leak before cleaning area.
4. Thoroughly clean the area around the leak with a stainless steel wire brush and, if necessary, emery paper to get to hard to reach areas. Use the brush on the epoxy as well as on the aluminum.

CAUTION: Do not use wire brushes that are not stainless steel.



5. Squeeze a bead (length) of Epoxi-Patch service material resin (Part A) on a clean, dry disposable flat mixing surface. Use uniform pressure to obtain an even bead.

   WARNING: OBSERVE ALL CAUTIONS AND WARNINGS PRINTED ON THE SERVICE MATERIAL CONTAINERS.
6. Squeeze an equal bead (length) of Epoxi-Patch hardener (Part B) parallel to the Part A bead. Mix Parts A and B together.
7. If it is necessary to have the epoxy flow to obtain a satisfactory repair, warm the core around the leak with a 375-watt heat lamp. Then, apply the Epoxi-Patch material to the leak.

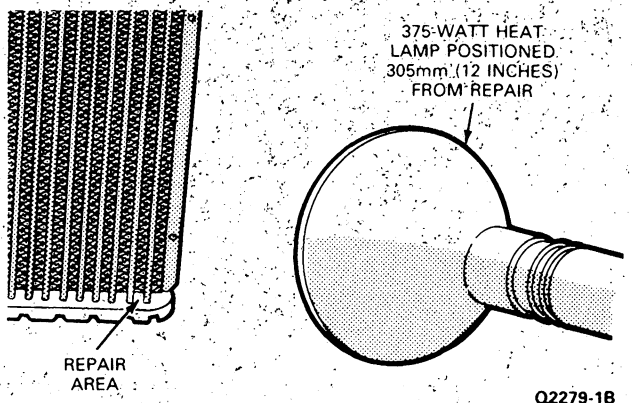


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SERVICE PROCEDURES (Continued)

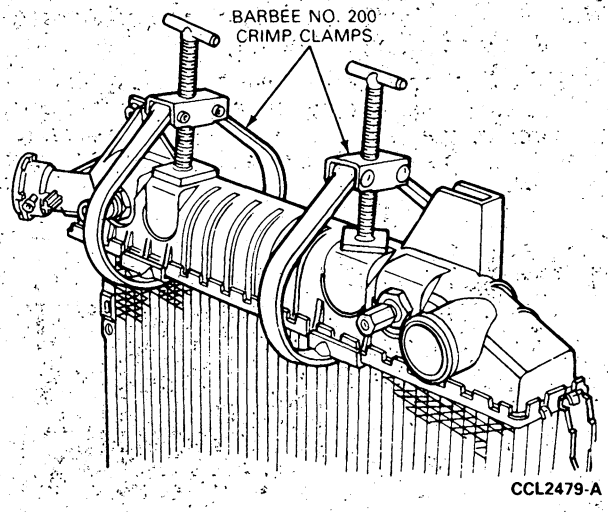
8. Position the 375 watt heat lamp 305mm (12 inches) from the service area and allow the epoxy to cure for two hours.

CAUTION: Do not position the heat lamp closer to the epoxy area than 305mm (12 inches). Do not use a heat gun or overheat the epoxy material.



9. When the epoxy is cured, test the service area. If tank has been removed clamp it to the header with No. 200 crimp clamps or equivalent to leak test.

10. After a successful leak test, paint if required. Install the radiator tank as outlined.

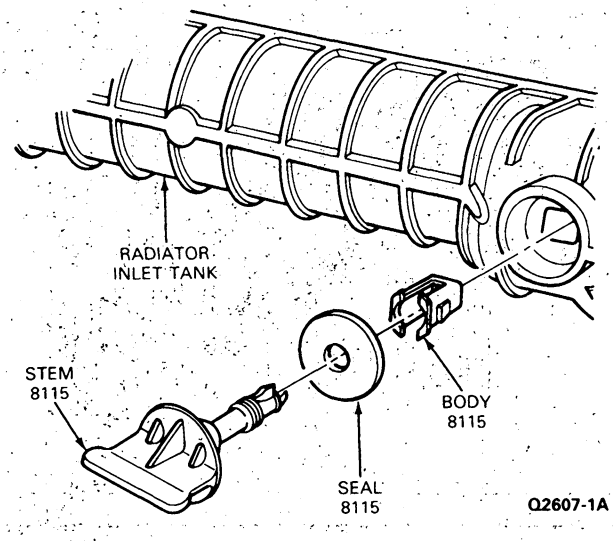


DRAINCOCK REPLACEMENT

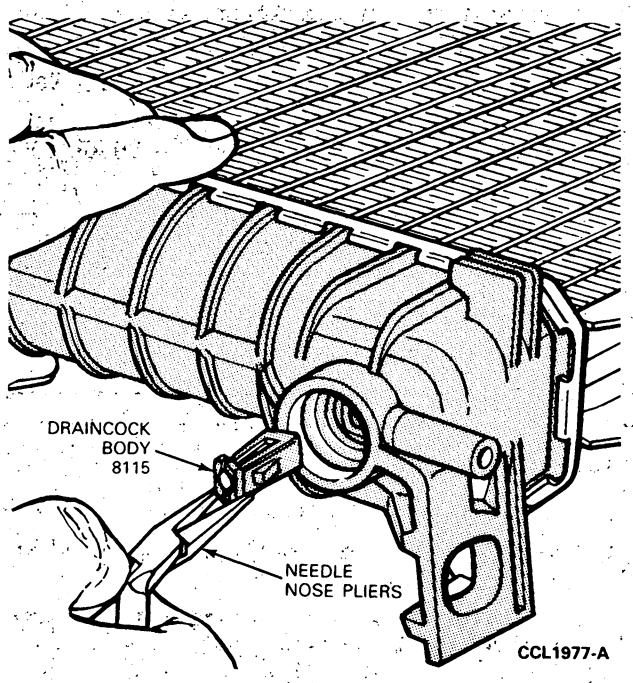
The draincock is located near the bottom of the inlet tank and can be replaced without removing the tank from the radiator. However, the radiator must be drained and should be removed from the vehicle for access to the draincock.

Removal

1. Turn the draincock stem counterclockwise to unscrew the stem and drain the radiator. After the radiator is drained, and when the stem is unscrewed to the end of the threads, pull the stem from the radiator tank and draincock body.



2. Remove the draincock body from the radiator tank by squeezing the sides together with a pair of needle nose pliers. Then, pull the body from the inlet tank.

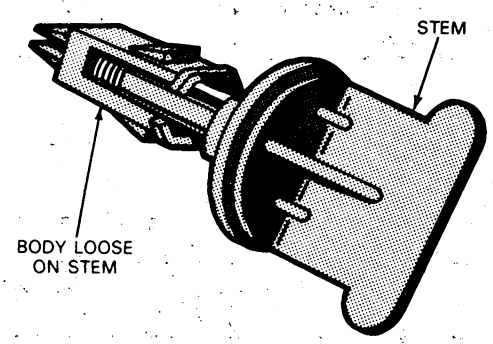


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SERVICE PROCEDURES (Continued)

Installation

1. Check the draincock to be sure the body is installed loosely on the stem. If the stem is screwed into the body, the draincock cannot be installed into the tank opening.
2. Push the loosely assembled draincock assembly body into the tank opening until it snaps into place.
3. Tighten the drain cock stem by turning clockwise to 2.0-2.7 N·m (18-25 lbs-in) torque.



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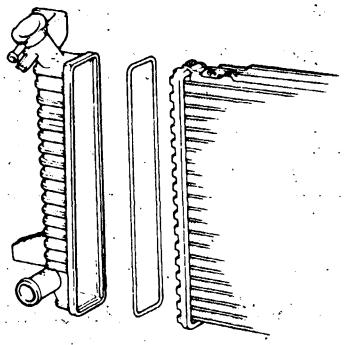
Oil Cooler Transfer Or Replacement

Removal

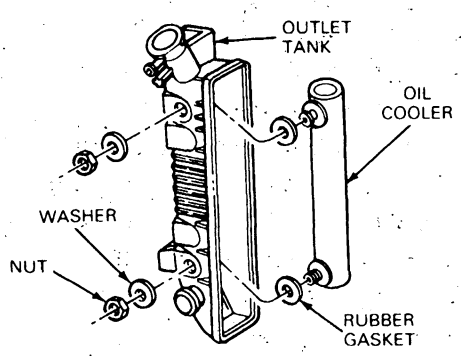
1. Remove the outlet tank from the radiator as outlined.
2. Remove the retaining nuts and washers from the oil cooler inlet and outlet connections. Then, lift the oil cooler from the radiator outlet tank.
3. Remove the rubber gaskets from the oil cooler inlet and outlet connections if the oil cooler is to be reused.

Installation

1. Install new rubber gaskets on the oil cooler inlet and outlet connections.
2. Position the oil cooler to the radiator outlet tank and insert the inlet and outlet connections through the holes in the outlet tank.
3. Install the flat washer and nut on each oil cooler connection to retain the oil cooler in the radiator outlet tank.
4. Tighten the oil cooler retaining nuts to 12-15 N·m (9-11 ft-lb).
5. Install the outlet tank on the radiator core header as outlined.



OUTLET TANK FOR V-8 ENGINE WITH STANDARD TRANSMISSION



NOTE: V8 RADIATOR SHOWN. I-6 RADIATOR HAS OIL COOLER AND FILLER NECK IN RH TANK

Q2608-1A

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SPECIFICATIONS

TORQUE SPECIFICATIONS

Description	N·m (ft.lbs.)	Description	N·m (ft.-lbs.)
Radiator to Body Sheet Metal E-150-E-350	14-20 (10-15)	Radiator Support to Frame Insulator Bolts	41-47 (30-35)
Radiator Hose Double Wire Clamp Bronco, F-150-F-350, E-150-E-350	2.26-3.39 (20-30 in-lbs.)	Shroud to Radiator F-150-F-350, Bronco, E-150-350	5.4-8 (4-6)
Radiator Hose Clamps Tangential Screw F-150-F-350, F-Super Duty and Bronco	2.8-3.9 (25-35 in-lbs.)	Transmission Oil Line Fitting to Radiator — F-150-F-350 and Bronco	24-31 (18-23)
Radiator Top Brackets to Radiator Support F-150-F-350 and Bronco	11-14 (8-11)	Transmission Oil Line Nut to Fitting on Radiator — F-150-F-350 and Bronco	17-24 (12-18)

COOLING SYSTEM PRESSURES (PSI)

	Operating Pressure	Min. Test Pressure
All Vehicles	13	10

CQ2609-2C

SPECIAL SERVICE TOOLS AND EQUIPMENT

- No. 200 Crimp Clamp:
  The Barbee Company
  P.O. Box 323
  Louisville, Kentucky 40201.
- No. 23151 Stainless Steel Wire Brush:
  The Milwaukee Brush Manufacturing Co.
  P.O. Box 830
  Menomonee Falls, Wisconsin 53051.
- Heat Lamp and Socket: 375 Watt.
- Epoxi-Patch Kit No. 6C Aluminum:
  Hysol Division of the Dexter Corporation
  Olean, New York 14760.
- Tool BT8260 and 8260-A Radiator Core Remover and Replacer:
  Borroughs Tool and Equipment Corporation
  2429 North Burdick St.
  Kalamazoo, Michigan 49007.

ROTUNDA EQUIPMENT

Model	Description
021-00012	Cooling System Pressurization Kit

CQ1713-1C

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SECTION 27-06 Accessory Drive Belt Service

SUBJECT	PAGE
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Belt Tension—Manually Tensioned Belts	27-06-7
DESCRIPTION	
Accessory Drive Belts	27-06-1
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Belt Tension—Automatically Tensioned Belts	27-06-7
Belt Tension—Manually Tensioned Belts	27-06-7
DIAGNOSIS AND TESTING (Cont'd)	
Diagnosis Guides	27-06-5
Testing	27-06-7
REMOVAL AND INSTALLATION	
Accessory Drive Belts	27-06-8
Automatic Tensioner	27-06-8
Automatically Tensioned Belts	27-06-8
Manually Tensioned Belts	27-06-8
SPECIFICATIONS	27-06-10
VEHICLE APPLICATION	27-06-1

VEHICLE APPLICATION

All Light Truck Models.

DESCRIPTION

Accessory Drive Belts

Ford trucks are equipped with either "V" drive belts or "poly-V" drive belts (Fig. 1). The belt type is selected for each engine based on performance requirements. To ensure maximum belt life, replacement belts should be of the same type and specification as originally installed.

These belts must be properly tensioned at all times. Loose belt(s) will result in slippage which may cause a noise complaint or improper accessory operation (alternator will not charge, etc.). Overly tight belts will place severe loads on accessory bearings and result in premature belt failure. Refer to Figures 2 through 5 for the belt routing of each particular engine.

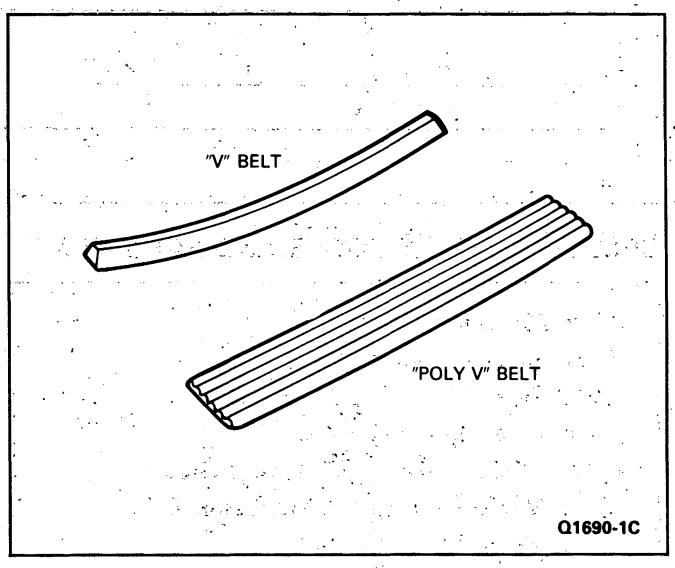


FIG. 1 Drive Belts

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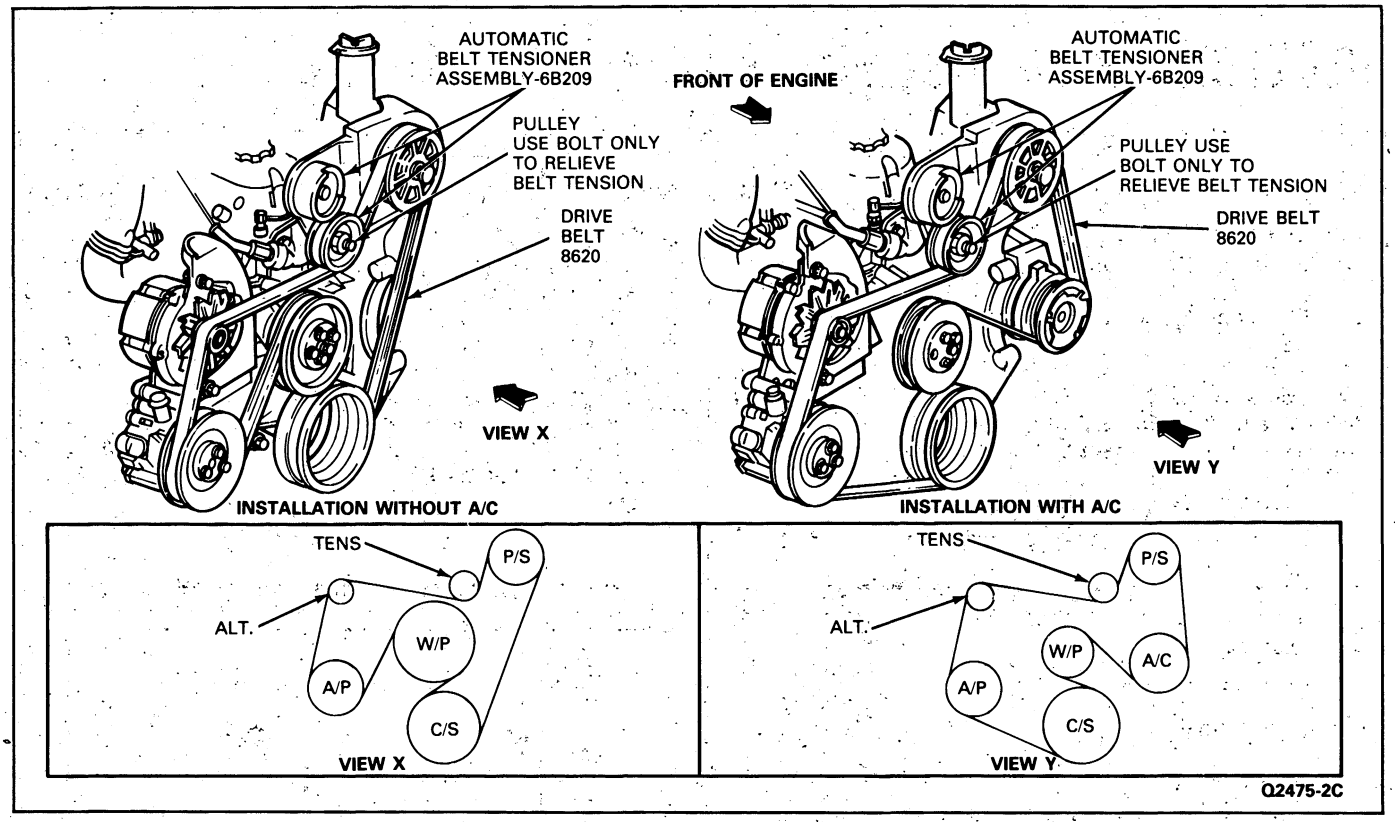


FIG. 2 4.9L EFI Engine Accessory Drive Belt

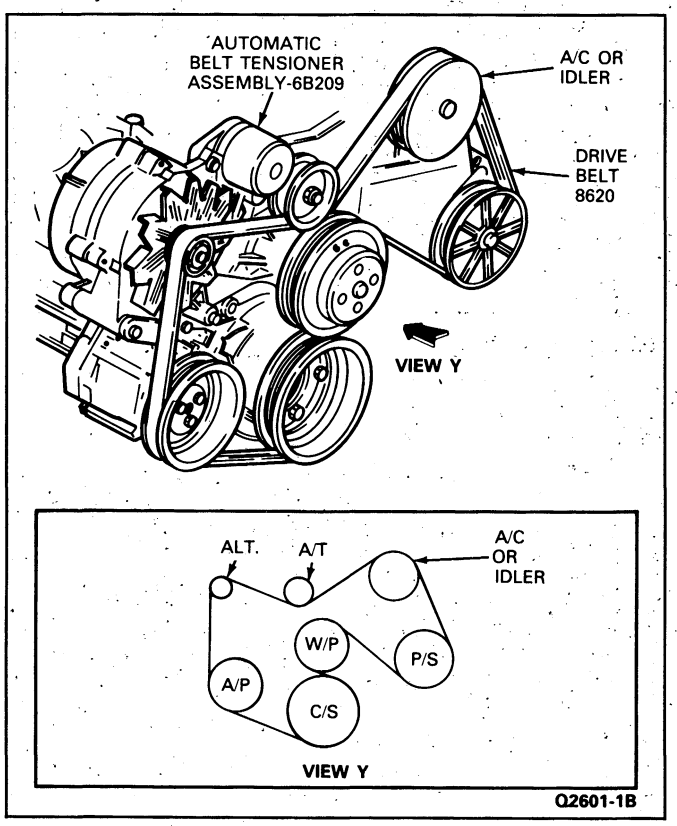


FIG. 3 5.0L-5.8L EFI Engines Accessory Drive Belt

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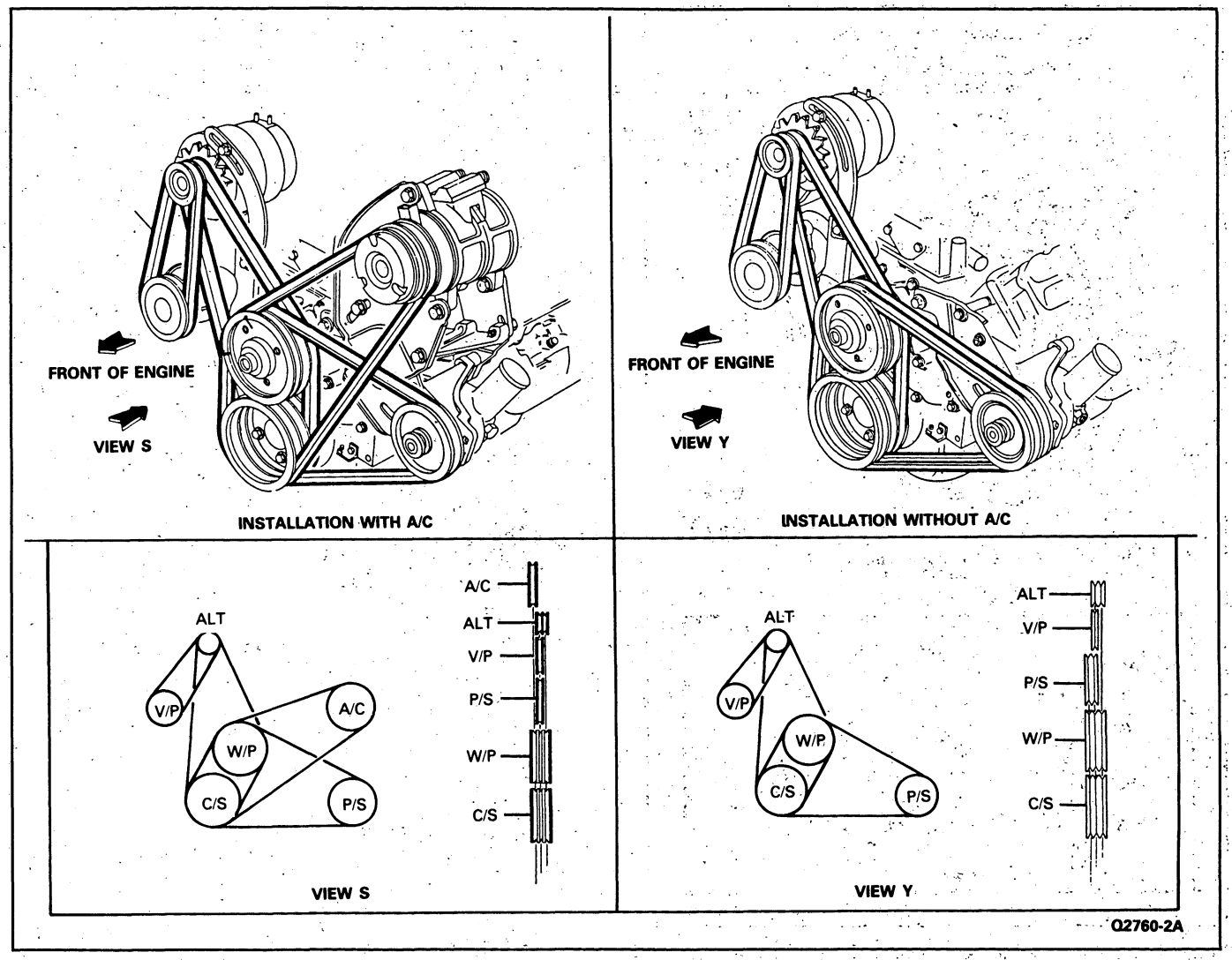


FIG. 4 7.3L Diesel Engine Accessory Drive Belt

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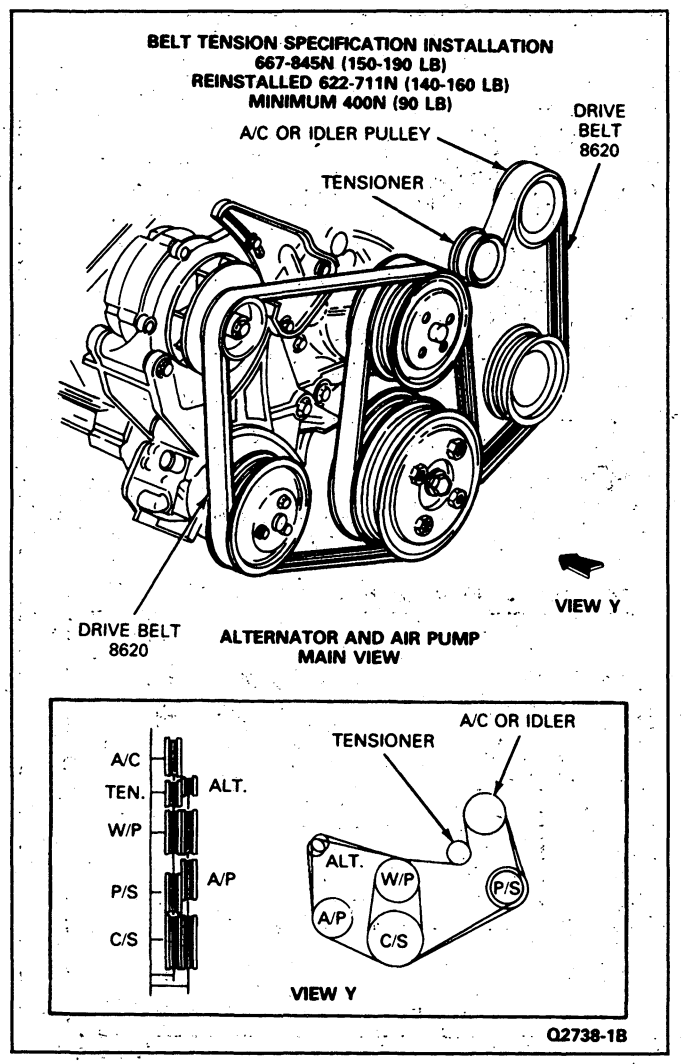


FIG. 5 7.5L EFI Engine Accessory Drive Belt

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DIAGNOSIS AND TESTING

Diagnosis Guides

Find complaint in the following Diagnosis Guides and perform the recommended actions.

ACCESSORY DRIVE BELT DIAGNOSIS GUIDE

CONDITION	POSSIBLE CAUSE	ACTION
Excessive Noise — Belt Squeal	Seized Accessory	Check all accessories for free rotation and replace accessory if necessary. Replace belt.
	Loose Belt	Check condition and tension of all belts. Replace belts or adjust tension of manually tensioned belts as necessary. Check that automatic tensioner is within operating range. Check for correct belt length if tensioner is out of operating range.
— Rattle	Loose Pulley or Accessory	Check for looseness and tighten.
Severe Belt Flutter	Loose Belt	Check belt tension and adjust (manually tensioned belts only) if necessary. Check condition of belt and replace if necessary.
	Binding Tensioner arm	Remove belt from automatic tensioner and verify that tensioner arm is not frozen in position or that arm does not bind when manually moved throughout its operating range.
Frayed Belt	Belt not Seated Correctly (poly "V" belt)	Replace belt and verify correct belt seating. Refer to Fig. 6.
	Severely Misaligned Pulley	Use a straight edge to check for severe angular misalignment between adjacent pulleys. Correct as necessary.
	Belt too Tight	Replace belt.
	Belt Worn Out	Replace belt.
Severely Glazed Belt	Seized Accessory	Check all accessories for free rotation and replace if necessary. Replace belt.
	Loose Belt	Replace belt.
Improper Accessory Operation (PS or AC doesn't work, engine overheats or battery doesn't charge)	Loose Belt	Check belt for looseness or glazing and replace or adjust tension of manually tensioned belts if necessary.
Belt Jumps off Pulley	Greatly Misaligned Pulleys	Check for misalignment between adjacent pulleys.
	Belt Not Seated Correctly ("poly V" belt)	Replace belt and verify correct seating. Refer to Fig. 6.
	Pulley Wobble	Verify that no pulley wobbles during engine operation. Conditions causing wobble are: bent pulley, bent accessory shaft, rear face of pulley not seated flat against mating surface.

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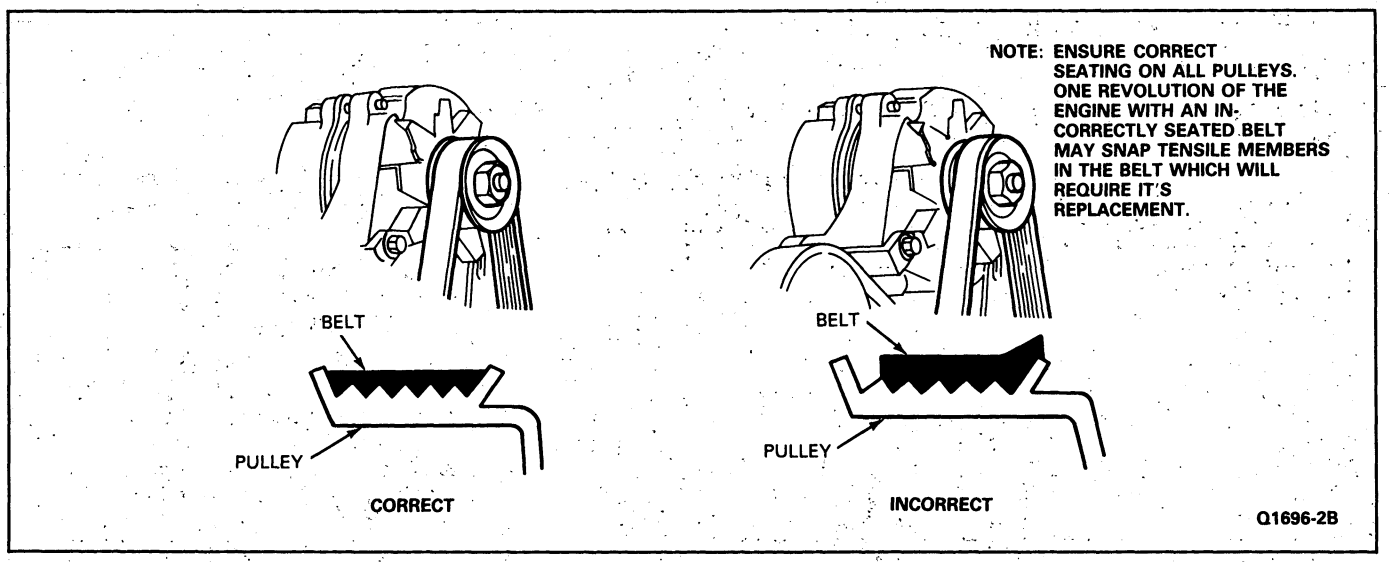


FIG. 6 Ribbed Belt Alignment

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Testing

Belt Tension—Manually Tensioned Belts

Use a Standard "V" Belt Tension Gauge T63L-8620-A or equivalent for "V" Belt Tension Gauge 021-00019 or equivalent for "poly V" belts. Tension measurements should be taken at midspan (Fig. 7). Refer to Specifications chart for the correct belt tensions.

Belt Tension—Automatically Tensioned Belts

The automatic belt tensioner will maintain correct belt tension if the correct length belt is on the engine. To verify that the tensioner is working properly check to see that the belt length indicator mark on the tensioner is between the maximum and minimum marks (Figs. 8, 9 and 10).

The belt tension can be checked as follows:

1. Install a 5/8 in. or 16 mm wrench on the tensioner pulley bolt and rotate the tensioner arm (Fig. 11) to relieve all tension from the belt. Slowly return arm to rest against the belt and measure belt tension.
2. Rotate arm against belt causing the pulley to deflect approximately 1/2 inch from it's rest position. Slowly release tension from arm and measure belt tension.
3. Average the two tensions and verify that result is above the minimum tension shown in Specifications chart.

ADJUSTMENTS

Belt Tension—Manually Tensioned Belts

A. Use Belt Tension gauge T63L-8620-A or equivalent for "V" belts or Belt Tension Gauge 021-00019 or equivalent for "poly V" belts.

B. Loosen accessory adjustment bolts and pivot bolts. Refer to Figs. 12 and 13.

C. All Belts except Alternator Belt—Insert a square drive ratchet wrench or breaker bar in the square hole in accessory bracket and tighten belt to correct tension.

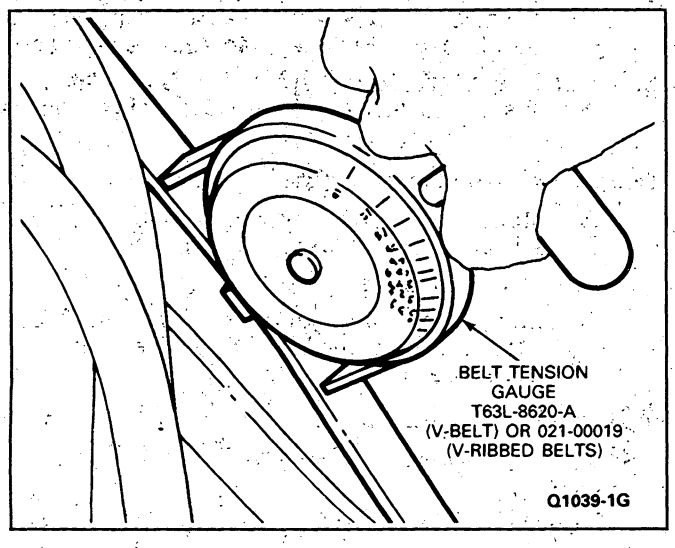


FIG. 7 Checking Belt Tension

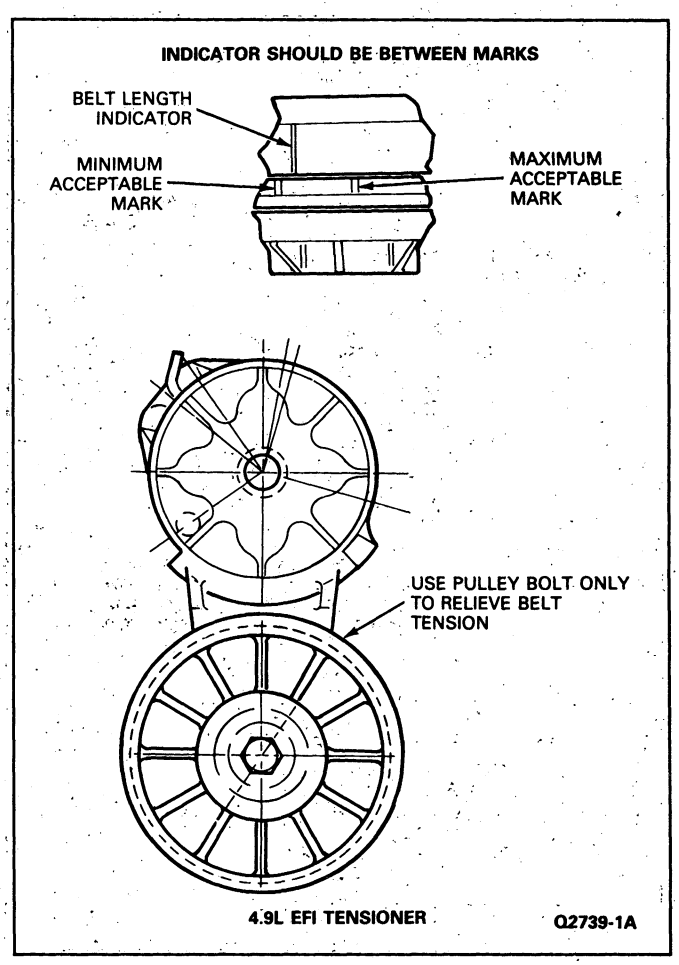


FIG. 8 4.9L EFI-Belt Length Indicator

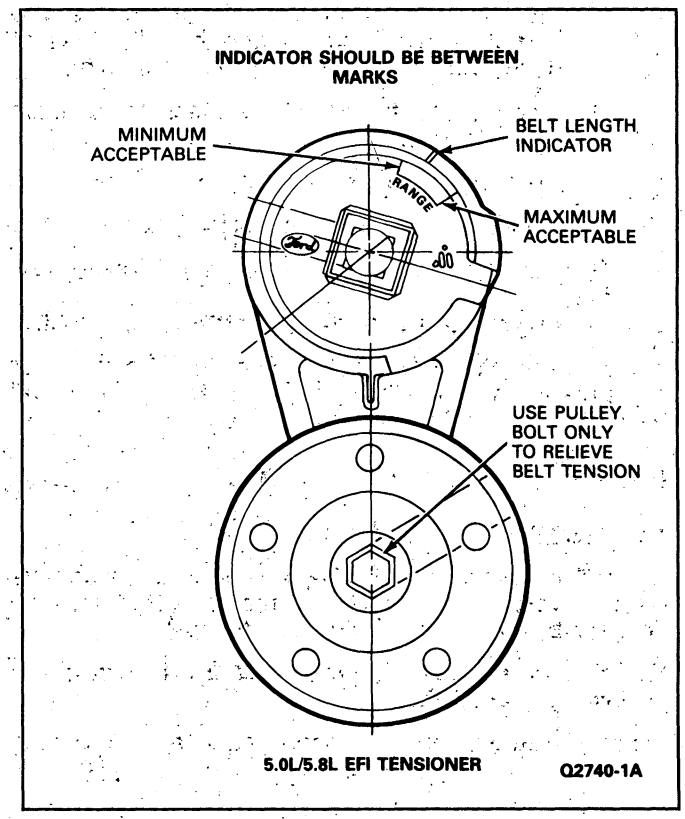


FIG. 9 5.0L-5.8L EFI-Belt Length Indicator

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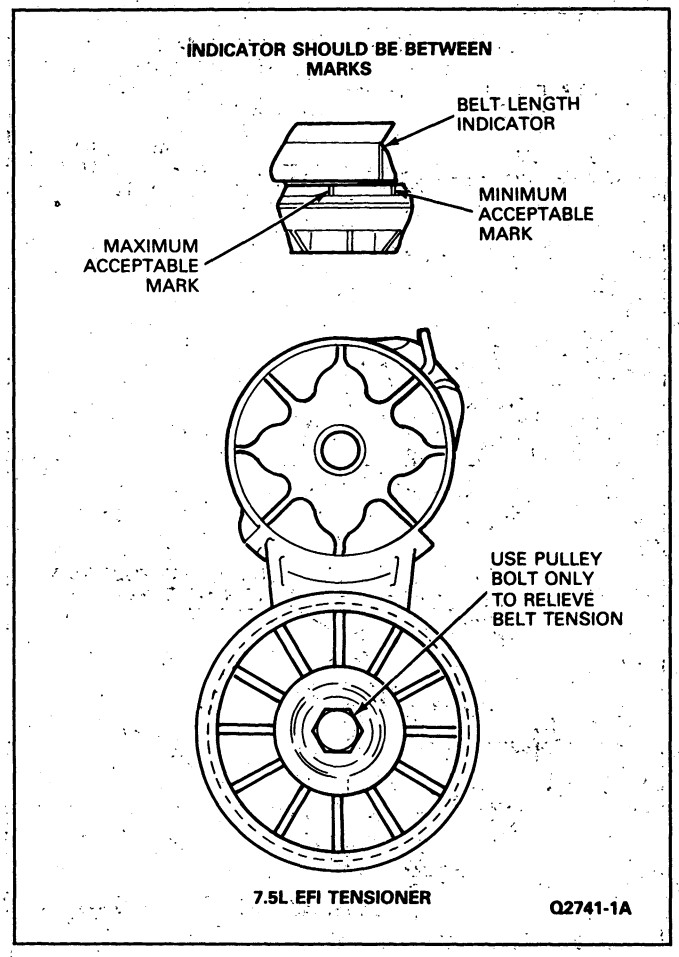


FIG. 10 7.5L EFI-Belt Length Indicator

Alternator Belt—Place a "C" clamp over the end of the adjusting arm and the adjusting bolt boss and tighten belt to correct tension.

D. Tighten adjustment bolt to specification while maintaining belt tension.

E. Remove square driver tool or "C" clamp.

F. Tighten pivot bolt to specification.

G. Check and readjust belt tension if necessary.

Belt Tension—Automatically Tensioned Belts

The automatic belt tensioner has no provision for adjustment and will be damaged if forced to travel beyond it's operating range.

REMOVAL AND INSTALLATION

Accessory Drive Belts

Conditions requiring belt replacement are excessive wear, severe glazing, frayed cords, etc. Replace any belt exhibiting any of these conditions.

NOTE: Minor cracks in the back of the belt are considered acceptable.

Proper removal and installation steps are as follows:

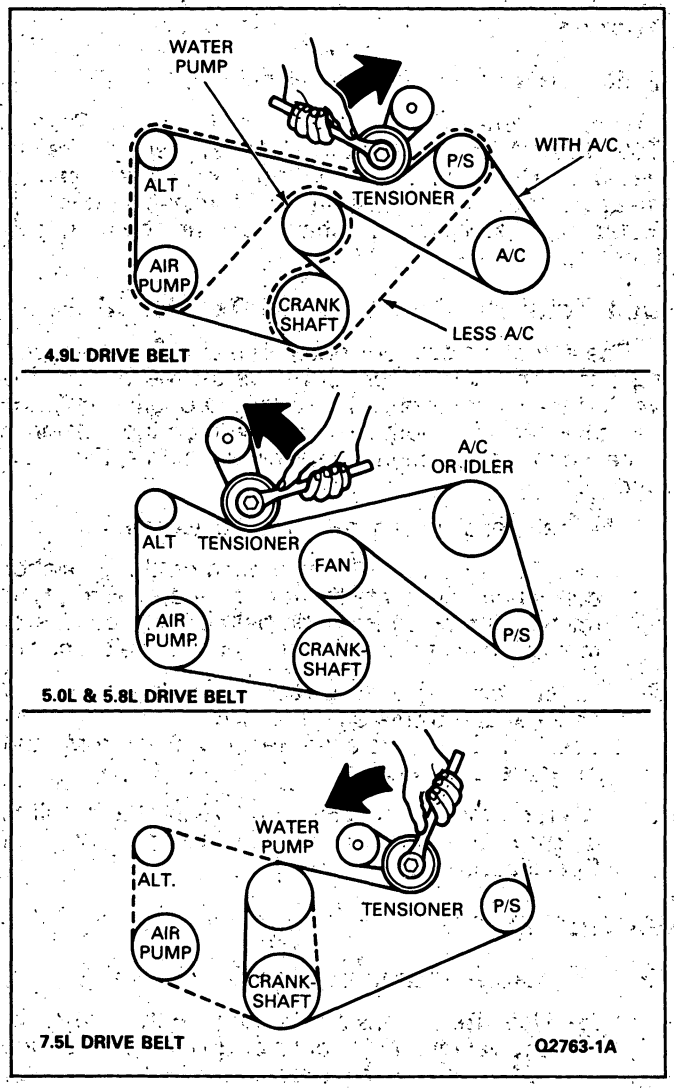


FIG. 11 Checking Belt Tension

Automatically Tensioned Belts

1. Install a 5/8 inch or 16 mm closed end wrench on the tensioner pulley bolt and lift the tensioner arm away from the belt as in Fig. 11.
2. Remove old belt. Release tensioner slowly. Do not allow tensioner to snap back after the belt is removed because this may damage the tensioner.
3. Install new belt over pulleys making sure that all six belt ribs are correctly seated in the pulley grooves as shown in Fig. 6.

Manually Tensioned Belts

A. Loosen accessory adjustment bolts and pivot bolt as shown in Figs. 12 and 13.

B. Remove old belt.

C. Install new belt and tension per "Belt Tension—Manually Tensioned Belts" procedure.

Automatic Tensioner

Remove and replace. Refer to Fig. 14.

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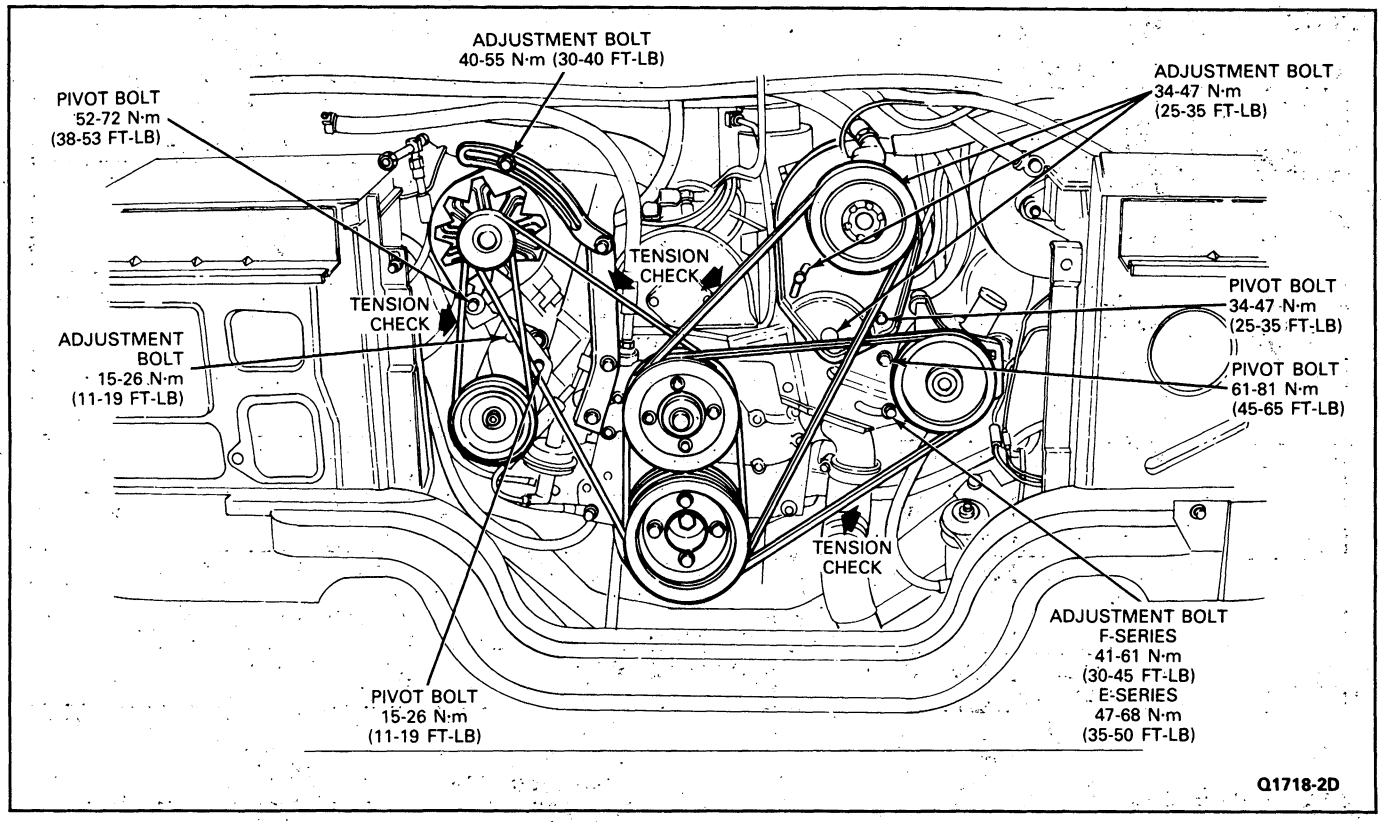


FIG. 12 7.3L Diesel Engine Accessory Drive Belts

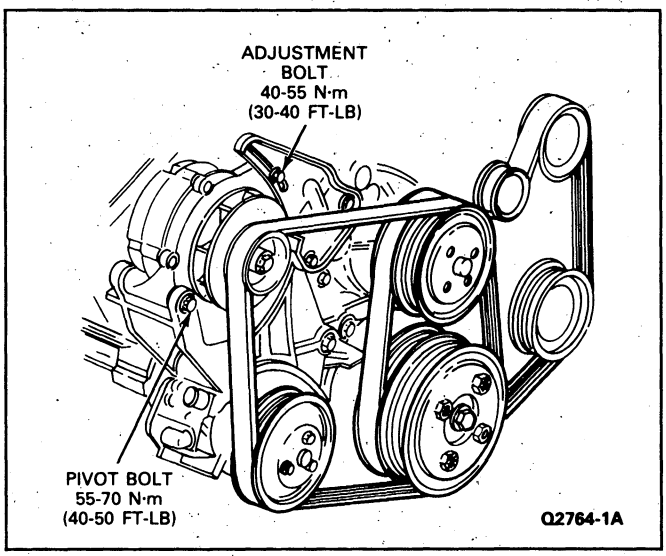
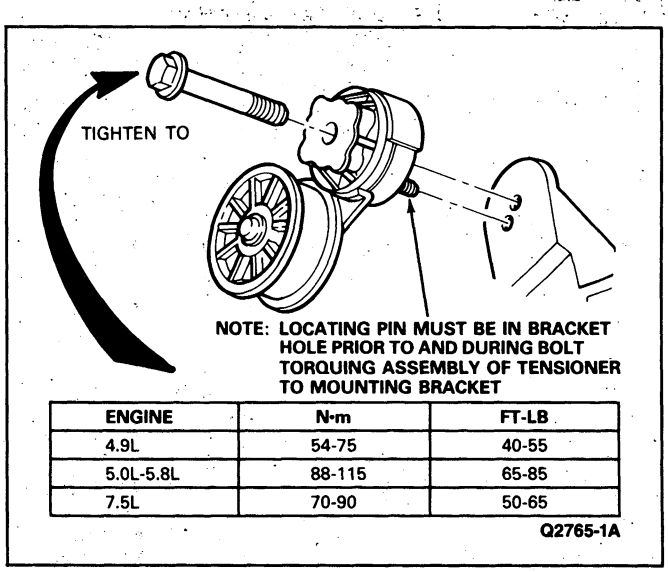


FIG. 13 7.5L EFI Engine Accessory Drive Belts



ENGINE	N·m	FT-LB
4.9L	54-75	40-55
5.0L-5.8L	88-115	65-85
7.5L	70-90	50-65

FIG. 14 Automatic Tensioner—Installation

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SPECIFICATIONS

ACCESSORY DRIVE BELT TENSION

Engine	Tensioning Method	Belt Type	Tension Newtons (Pounds) (0 Min. Operation)	Tension Newton (Pounds) (> 10 Min. Operation)
4.9L	Automatic	6K "poly V" belt	Tension OK if tensioner within indicator marks. F Series & Bronco 400 N (90 lb.) min. Econoline 520 N (117 lb.) min.	Same as new
5.0L 5.8L	Automatic	6K "poly V" belt	Tension OK if tensioner within indicator marks. F Series & Bronco 343 N (77 lb.) min. Econoline 494 N (111 lb.) min.	Same as new
7.3L	Manual	Vac. Pump "V" belt 9.5 mm (3/8 in)	400-578 N (90-130 lb.)	318 N min. (72 lb.)
		All Other "V" belt 12.7 mm (1/2 in)	622-800 N (140-180 lb.)	462 N min. (104 lb.)
7.5L	(A/C & P/S belt) Automatic	6K "poly V" belt	Tension OK if tensioner within indicator marks. 418 N (94 lb.) min.	Same as new
	(Alt & Air Pump belt) Manual	6K "poly V" belt	711-889 N (160-200 lb.)	520 N min. 117 lb. min.

CQ2766-2A

SPECIAL SERVICE TOOLS

Tool No.	Description
T63L-8620-A	Standard V-Belt Tension Gauge

CQ2126-1A

ROTUNDA EQUIPMENT

Model No.	Description
021-00019	V-Ribbed Belt Tension Gauge

CQ2743-1A

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SECTION 27-09 Fan and Clutch—Engine Operated

SUBJECT	PAGE
DESCRIPTION AND OPERATION	27-09-1
REMOVAL AND INSTALLATION	
Fan and Viscous Clutch	27-09-1
4.9L EFI	27-09-1
5.0L, 5.8L AND 7.5L ENGINES	27-09-2
REMOVAL AND INSTALLATION (Cont'd.)	
Fan and Viscous Clutch (Cont'd.)	
7.3L DIESEL	27-09-2
SPECIAL SERVICE TOOLS	27-09-3
VEHICLE APPLICATION	27-09-1

VEHICLE APPLICATION

All Models.

DESCRIPTION AND OPERATION

The fan and viscous clutch assembly is used to cool the engine. The fan is driven by the engine through the use of a drive belt(s).

If the fan drive belt(s) is noisy check for correct belt tension or misaligned pulleys. Refer to Section 27-06 for belt tension specifications. If a drive belt is worn or frayed, replace it. Refer to Section 27-06, Accessory Drive Belt Service.

REMOVAL AND INSTALLATION

Fan and Viscous Clutch

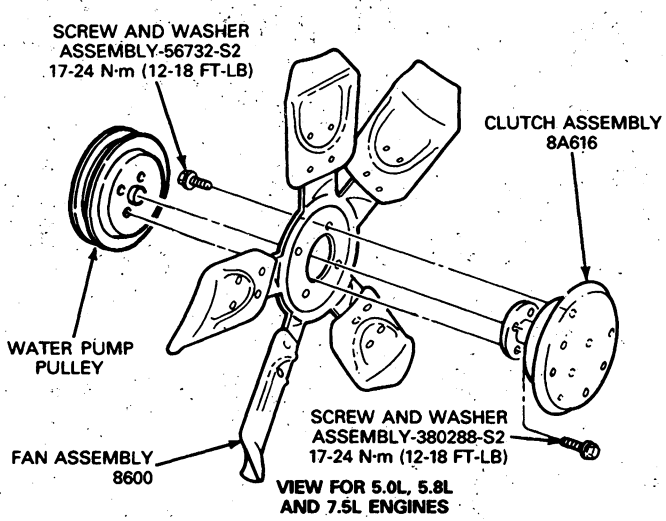
4.9L EFI

Removal

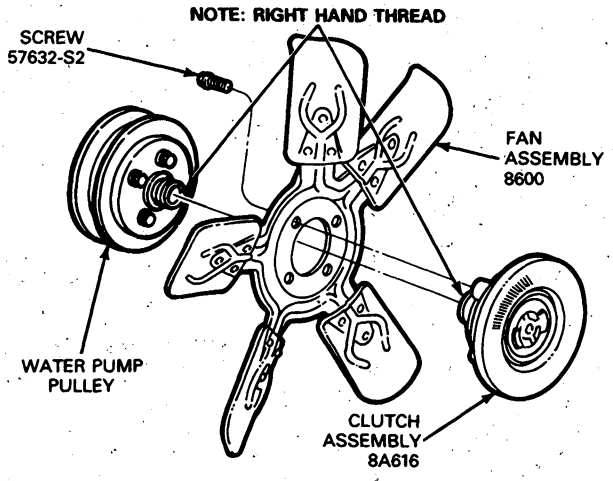
1. Remove the fan shroud. Refer to Section 27-04, Radiators.
2. Remove one bolt securing the fan to the clutch.
3. Remove the clutch assembly from the water pump by turning the large nut, which is part of the clutch, using Fan Clutch Holding Tool T84T-6312-C and Fan Clutch Nut Wrench T84T-6312-D or equivalents.

CAUTION: This nut has a RIGHT-HAND thread and must be rotated counterclockwise to remove it.

4. Remove the fan and clutch assembly.
5. If the fan and clutch have to be separated, remove the remaining bolts attaching the fan to the clutch.



VIEW FOR 5.0L, 5.8L AND 7.5L ENGINES



VIEW FOR 4.9L ENGINES Q1519-2G

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REMOVAL AND INSTALLATION (Continued)

Installation

1. Install all but one of the bolts attaching the fan to the clutch.
2. Install the fan/clutch assembly on the water pump hub by turning the large nut, which is part of the clutch, using Fan Clutch Holding Tool T84T-6312-C and Fan Clutch Nut Wrench T84T-6312-D or equivalents.

CAUTION: This nut has a RIGHT-HAND thread and must be rotated clockwise to tighten it.

Tighten to 41 N·m (30 ft-lb).

3. Install the last bolt in fan/clutch assembly. Tighten all bolts to 17-24 N·m (12-18 ft-lb).
4. Install the fan shroud. Refer to Section 27-04, Radiators.

5.0L, 5.8L AND 7.5L ENGINES

Removal

1. Remove shroud and radiator if necessary. Refer to Section 27-04, Radiators.
2. Remove four screws retaining clutch on water pump hub.
3. Pull clutch and fan assembly off water pump pilot and remove assembly from vehicle.
4. Remove four screws and separate clutch from fan.

Installation

1. Position fan to clutch assembly and attach with four screws. Tighten screws to 17-24 N·m (12-18 ft-lb).
2. Position fan and clutch assembly to water pump pulley and attach with four screws. Tighten screws to 17-24 N·m (12-18 ft-lb).
3. Install the fan shroud. Refer to Section 27-04, Radiators.

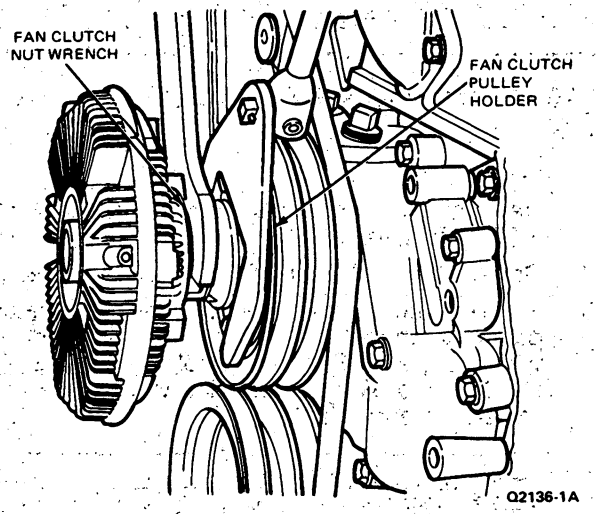
7.3L DIESEL

Removal

1. Remove the fan shroud. Refer to Section 27-04, Radiators.
2. Remove the clutch assembly from the water pump shaft by turning the nut, which is part of the clutch, using Fan Clutch Pulley Holder T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B or equivalents.

CAUTION: This nut has a LEFT-HAND thread and must be rotated clockwise for removal.

3. Remove the fan and clutch as an assembly.
4. Remove the bolts attaching the fan to the clutch, if necessary.



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REMOVAL AND INSTALLATION (Continued)

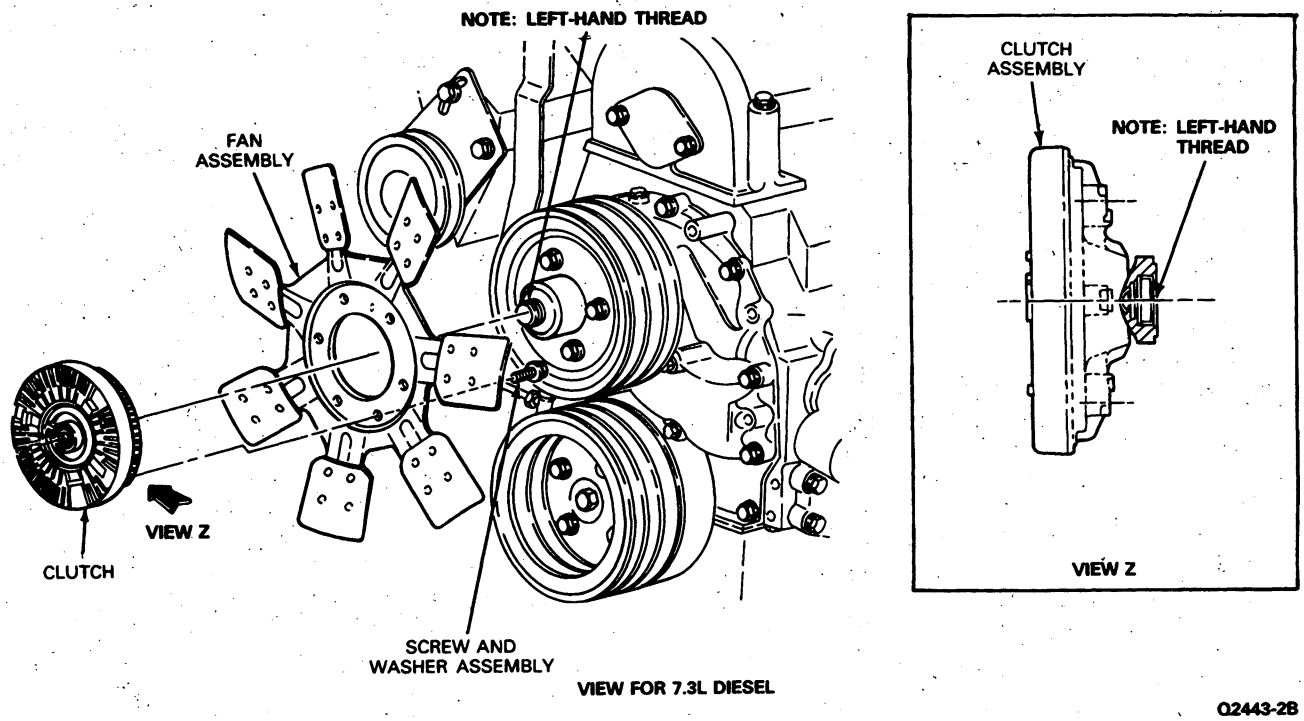
Installation

1. Install the bolts attaching the fan to the clutch. Tighten to 17-24 N·m (12-18 ft-lb).
2. Install the clutch/fan assembly on the water pump by turning the large nut which is part of the clutch.

CAUTION: This nut has a LEFT-HAND thread and must be rotated counterclockwise for tightening.

Tighten to 54-163 N·m (40-120 ft-lb) using Fan Clutch Holding Tool T83T-6312-A and Fan Clutch Nut Wrench T83T-6312-B or equivalents.

3. Install the fan shroud. Refer to Section 27-04, Radiators.



VIEW FOR 7.3L DIESEL

Q2443-2B

SPECIAL SERVICE TOOLS

SPECIAL SERVICE TOOLS

Model	Description
T84T-6312-C	Fan Clutch Holding Tool
T84T-6312-D	Fan Clutch Nut Wrench
T83T-6312-A	Fan Clutch Pulley Holder
T83T-6312-B	Fan Clutch Nut Wrench

CQ2444-1A

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GROUP 28 STARTING SYSTEM

(11000)

SECTION TITLE	PAGE
POSITIVE ENGAGEMENT STARTER	28-02-1
STARTING SYSTEM GENERAL SERVICE	28-01-1

SECTION 28-01 Starting System General Service

SUBJECT	PAGE
DESCRIPTION	28-01-1
DIAGNOSIS GUIDE	
Jump Starting	28-01-2
VEHICLE APPLICATION	28-01-1

VEHICLE APPLICATION

All Models.

DESCRIPTION

The function of the starting system is to crank the engine at a speed fast enough to permit the engine to start. Heavy cables, connectors, and switches are used in the starting system because of the large amount of current required by the starter while it is cranking the engine. The amount of resistance in the starting circuit must be kept to an absolute minimum to provide maximum current for starter operation. Loose or corroded connections, relay contacts, or partially broken cables will result in slower than normal cranking speeds, and may even prevent the starter from cranking the engine.

Refer to the Wiring Diagrams Manual for electrical schematic wiring diagrams and the locations of wiring harnesses.

DIAGNOSIS GUIDE

Use the Diagnosis Guide in this Section to assist in locating the possible cause of any starter complaint that may occur. Refer to Section 28-02 for detailed diagnosis and testing.

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CONDITION	POSSIBLE CAUSE	RESOLUTION
Engine will not crank.	1. Loose, corroded, or broken cables or connectors.	1. Clean and tighten cable connections — check wire strands in eyelets. Replace if necessary.
	2. Undercharged battery.	2. Check battery. Charge or replace.
	3. Burned fusible link in main wire feed to ignition switch.	3. Check fusible link and replace if necessary.
	4. Starter relay	4. Check all connections and two mounting screws. With transmission in PARK or NEUTRAL, connect a jumper from the small terminal of the starter relay to the battery. If this jumper activates starter, check wiring to relay, ignition switch, neutral switch or clutch interlock switch for open or loose connections. If relay is not activated by jumper, replace relay.
	5. Loose, corroded or open wiring — ignition switch, neutral switch, or clutch interlock switch.	5. Clean and tighten connections or replace wiring. Replace switches if necessary.
	6. Starter motor.	6. Repair or replace as required.
Engine will not crank — starter relay clicks.	1. Loose cable connections at relay or starter.	1. Clean and tighten cable connections — check wire strands in eyelets.
	2. Undercharged battery.	2. Check battery. Charge or replace.
	3. Starter motor.	3. Repair or replace as required.
Engine will not crank — starter spins.	1. Starter motor.	1. Remove starter and inspect drive. Replace as required.
	2. Flywheel ring gear.	2. Remove starter and inspect ring gear teeth (also starter drive pinions). Replace as required.
Engine cranks continuously with key off.	1. Starter relay.	1. Replace starter relay.
Engine cranks slowly.	1. Loose connections or corroded battery cables.	1. Clean and tighten cable connections.
	2. Undercharged battery.	2. Check battery. Charge or replace.
	3. Starter motor.	3. Repair or replace as required.

CJ3544-2B

Jump Starting

Refer to Figs. 1 and 2.

The following instructions for starting the vehicle with jumper cables contain precautions that should be observed to avoid possible injury, or damage to the vehicle.

WARNING: KEEP BATTERIES OUT OF REACH OF CHILDREN. THEY CONTAIN SULFURIC ACID. AVOID CONTACT WITH SKIN, EYES OR CLOTHING. ALSO, SHIELD YOUR EYES WHEN WORKING NEAR THE BATTERY TO PROTECT AGAINST POSSIBLE SPLASHING OF THE ACID SOLUTION. IN CASE OF ACID CONTACT WITH SKIN, EYES, OR CLOTHING, FLUSH IMMEDIATELY WITH WATER FOR A MINIMUM OF 15 MINUTES. IF ACID IS SWALLOWED, DRINK LARGE QUANTITIES OF MILK OR WATER, FOLLOWED BY MILK OF MAGNESIA, A BEATEN EGG OR VEGETABLE OIL. CALL A PHYSICIAN IMMEDIATELY.

WARNING: HYDROGEN AND OXYGEN GASES ARE PRODUCED DURING NORMAL BATTERY OPERATION. THIS GAS MIXTURE CAN EXPLODE IF FLAMES, SPARKS OR LIGHTED TOBACCO ARE BROUGHT NEAR THE BATTERY. WHEN CHARGING OR USING A BATTERY IN AN ENCLOSED SPACE, ALWAYS PROVIDE VENTILATION AND SHIELD YOUR EYES.

CAUTION: Use only a 12-volt jumper system. A 12-volt starting motor and ignition system can be damaged beyond repair by connecting it to a 24-volt power supply (two 12-volt batteries in series, or a 24-volt motor generator set).

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CAUTION: Follow procedure in exact sequence.

CAUTION: Filament failures of headlamps can occur when vehicle with a dead battery is jump started. Place the main light switch in OFF position.

CAUTION: Do not allow vehicles to touch.

1. Turn all lamps off before and during jump starting.
2. Turn on heater blower motor to remove transient voltage.
3. Shield eyes. Use safety goggles or similar eye protection.
4. Connect end of one cable to positive (+) terminal of discharged battery and the other end to the positive (+) terminal of the "good" battery.

NOTE: On F-250—F-350 and F-Series Super Duty with 7.3L diesel engine, for optimum power and safety, connect booster cable to battery on passenger side of vehicle to be started (Fig. 2).

5. Connect one end of the other cable to negative (–) terminal of "good" battery.
6. Connect other end of cable to engine bolthead or similar good contact spot on the vehicle being started (NOT to negative (–) terminal of battery).
7. To prevent damage to other electrical components on vehicle being started, ensure that engine is at idle speed before disconnecting jumper cables.
8. Remove cable from engine block first, then other end of negative cable. Disconnect cable from battery positive terminal of good battery before disconnecting positive cable from discharged battery. Lamps may now be turned on.

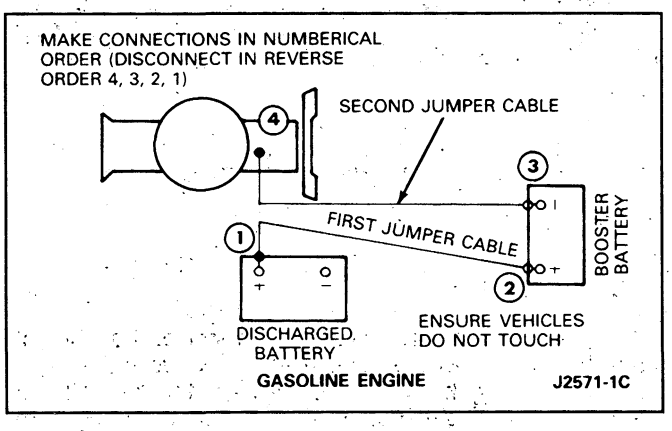


FIG. 1 Jump Starting Gasoline Engine

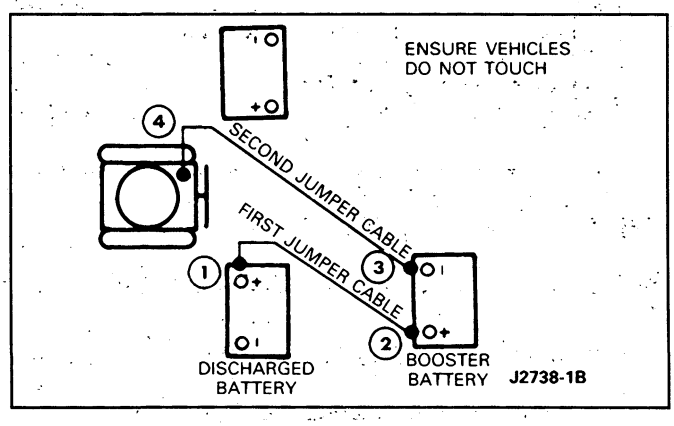


FIG. 2 Jump Starting Diesel Engine

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SECTION 28-02 Positive Engagement Starter

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DESCRIPTION AND OPERATION	28-02-1
DISASSEMBLY AND ASSEMBLY	
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Brush Replacement	28-02-5
Cleaning and Inspection	28-02-3
Starter Drive Replacement	28-02-4
REMOVAL AND INSTALLATION	28-02-2
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TESTING	
Bench Tests	28-02-2
Armature and Field Grounded Circuit Test	28-02-2
Armature Open Circuit Test	28-02-2
Starter No-Load Test	28-02-2

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If Starter Cranks Slowly	28-02-1
If Starter Does Not Crank and Relay Chatters Or Does Not Click	28-02-2
If Starter Does Not Crank But Starter Relay Operates (Clicks)	28-02-2
If Starter Spins (Humming Noise) But Does Not Crank Engine	28-02-2
Starter Load Test	28-02-2
Road Service	28-02-1
VEHICLE APPLICATION	28-02-1

VEHICLE APPLICATION

All Models with Gasoline and Diesel Engines.

DESCRIPTION AND OPERATION

The starting system includes the starter motor with an integral positive-engagement drive, the battery, a remote control starter switch (part of the ignition switch), the neutral start switch (used with automatic transmissions), the starter relay, starter interlock switch (used with manual transmissions except F-Super Duty Commercial Stripped Chassis with manual transmission), and heavy circuit wiring (Fig. 1).

Turning the ignition key to the START position actuates the starter relay through the starter control circuit. The starter relay then connects the battery to the starter.

In the starter control circuit, vehicles equipped with an automatic transmission have a neutral start switch; while vehicles equipped with a manual transmission have a starter interlock switch. This prevents operation of the starter if the selector lever is not in the N (NEUTRAL) or P (PARK) position (automatic) or clutch depressed (manual).

When the starter is not in use, one of the field coils is connected directly to ground through a set of contacts (Fig. 1). When the starter is first connected to the battery, current flows through the grounded field coil, actuating a movable pole shoe. The pole shoe is attached to the starter drive plunger lever and thus the drive is forced into engagement with the flywheel ring gear.

When the movable pole shoe is fully seated, it opens the field coil grounding contacts and the starter is then in normal operation. Normal field current is used to maintain the movable pole shoe in the fully seated position during the time that the starter is cranking the engine.

TESTING

Road Service

On road service calls or cases of a starter that will not crank the engine or a starter that cranks very slowly, a booster battery may be connected to the 12-volt system. Refer to Section 28-01, Starting System General Service. If the engine still will not turn with the booster connected, refer to the following tests:

On Vehicle Testing

If Starter Cranks Slowly

1. BATTERY—Use jumper cables per instructions in Section 28-01, Starting System General Service. If this corrects the problem, check condition of battery. Recharge or replace if necessary. Clean battery posts, cable lugs and tighten. Refer to Section 31-02, Batteries for battery service procedures.
2. CABLES—If Step 1 does not correct problem, clean and tighten connections at starter, relay and battery ground on engine. Eyelet terminals should not be easily rotated by hand. Also, check for short to ground.
3. STARTER—If above Steps do not correct problem, remove starter.

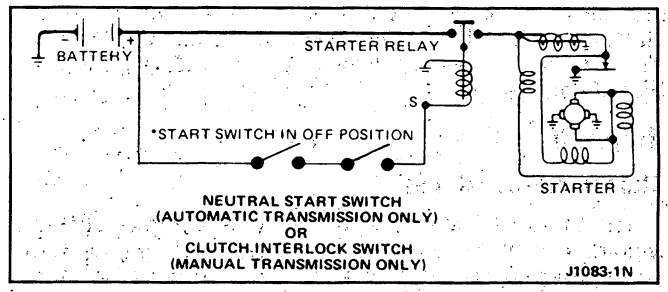


FIG. 1 Starting Circuit

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If Starter Does Not Crank But Starter Relay Operates (Clicks)

1. BATTERY—Use jumper cables, check battery, etc., as above.
2. CABLE—Clean and tighten connections at starter and relay. Ensure wire strands are secure in eyelets.
3. STARTER—If above steps do not correct problem, remove starter and perform bench tests to determine cause of problem. Repair or replace as required.

If Starter Does Not Crank and Relay Chatters Or Does Not Click

1. BATTERY—Use jumper cables, check battery, etc. as above.
2. RELAY—Remove push-on connector from relay (red w/blue stripe wire). Ensure connection is clean and secure. Ensure relay bracket is grounded.

   If connections are good, check operation by jumping with push-on connection off and transmission in PARK or NEUTRAL. Jumper above described terminal to relay main terminal (BAT side) or battery positive post. If this corrects problem, check ignition switch, neutral switch or clutch interlock switch and wiring in start circuit for open of loose connections.

   If jumper across relay does not correct problem, replace relay.

If Starter Spins (Humming Noise) But Does Not Crank Engine

STARTER—Remove and check armature shaft for corrosion. Clean or replace. If no corrosion, repair starter or replace starter drive.

Starter Load Test

Conduct this test if the starter cranks slowly and a comparison of the current output with specifications is desired.

Connect the test equipment as shown in Fig. 2. Ensure no current is flowing through the ammeter and heavy-duty carbon pile rheostat portion of the circuit (rheostat at maximum counterclockwise position).

Crank the engine with the ignition OFF, and determine the exact reading on the voltmeter. This test is accomplished by disconnecting the push-on connector "S" at the starter relay and by connecting the remote control starter switch from the positive battery terminal to the "S" terminal of the starter relay.

Stop cranking the engine. Then, reduce the resistance of the carbon pile until the voltmeter indicates the same reading as that obtained while the starter cranked the engine. The ammeter will indicate the starter current draw under load. Refer to Specifications.

Bench Tests

Starter No-Load Test

The starter no-load test will uncover open or shorted windings, rubbing armature, and bent armature shaft. The starter can be tested, at no-load, on the test bench only.

CAUTION: Secure starter to vise or fasten securely in similar fixture as starter generated torque may propel starter off bench.

Make the test connections as shown in Fig. 3, using a Rotunda 078-00005 Starting and Charging Tester. The starter will run at no-load. Ensure no current is flowing through the ammeter (rheostat at maximum counterclockwise position). Determine the exact reading on the voltmeter.

Disconnect the starter from the battery. Then, reduce the resistance of the rheostat until the voltmeter indicates the same reading as that obtained while the starter was running. The ammeter will indicate the starter no-load current draw. Refer to Specifications.

Armature Open Circuit Test

An open circuit armature may sometimes be detected by examining the commutator for evidence of burning. A spot burned on the commutator is caused by an arc formed every time the commutator segment, connected to the open circuit winding, passes under a brush.

Armature and Field Grounded Circuit Test

This test will determine if the winding insulation has been damaged, permitting a conductor to touch the frame or armature core.

To determine if the armature windings are grounded, make the connections as shown in Fig. 4. If the voltmeter indicates any voltage, the windings are grounded.

Grounded field windings can be detected by making the connections as shown in Fig. 5. If the voltmeter indicates any voltage, the field windings are grounded.

REMOVAL AND INSTALLATION

Removal

1. Disconnect negative battery cable.
2. Raise vehicle on a hoist.
3. Disconnect starter cable at starter terminal.
4. Remove starter mounting bolts. Remove starter assembly (Fig. 6).

Installation

1. Position starter assembly to flywheel housing, and start mounting bolts.
2. Snug all bolts while holding starter squarely against its mounting surface and fully inserted into pilot hole. Tighten bolts to 21-27 N·m (15-20 ft-lb).
3. Connect starter cable.
4. Lower vehicle. Connect negative battery cable to battery. Check operation of starter.

DISASSEMBLY AND ASSEMBLY

Use the following procedure when it becomes necessary to completely overhaul the starter. Figs. 7 and 8 illustrate a disassembled starter.

Disassembly

1. Remove cover screw and cover.
2. Remove the pivot pin retaining starter plunger lever. Remove through-bolts, the starter drive end housing, and lever return spring. Remove plunger lever and armature.

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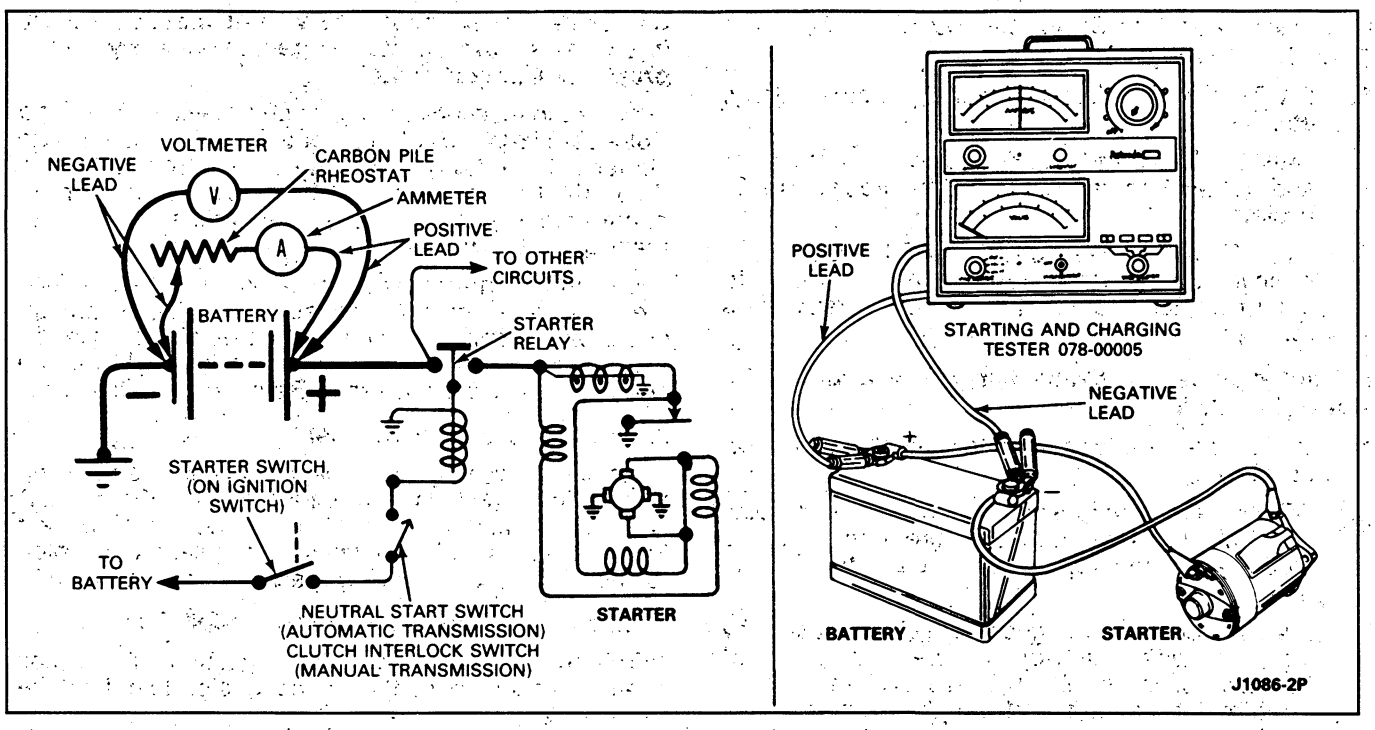


FIG. 2 Starter Load Test

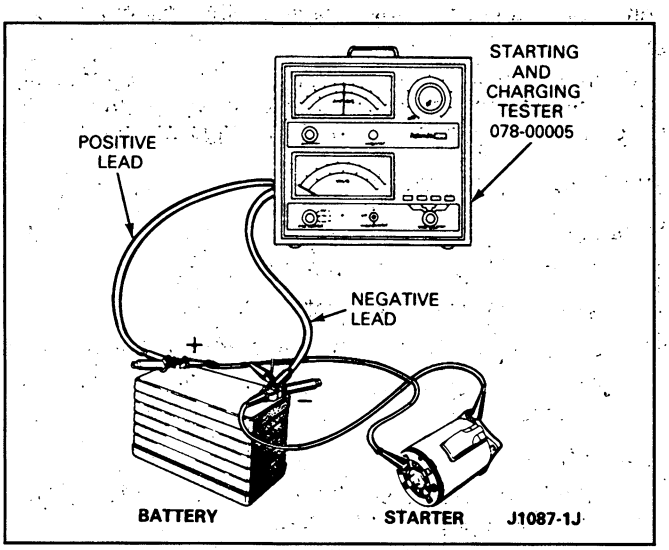


FIG. 3 Starter No-Load Test on Test Bench

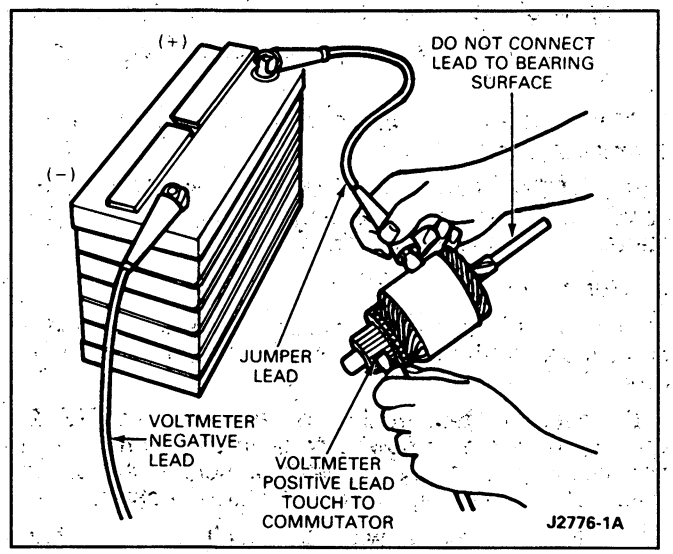


FIG. 4 Armature Grounded Circuit Test

3. Remove thrust washer and stop ring retainer. Remove and discard stop ring retaining starter drive to end of the armature shaft, and remove starter drive assembly.
4. Remove brush end plate and insulator assembly.
5. Remove brushes from plastic brush holder and lift out brush holder. Note location of brush holder with respect to end terminal.
6. Remove two screws retaining ground brushes to frame. (Four-inch starter has copper rivets.)
7. On field coil that operates starter drive gear actuating lever, bend edges on field coil retaining sleeve and remove sleeve and retainer.
8. Remove three coil retaining screws using an arbor press (Fig. 9). The arbor press prevents the wrench from stripping out head of screw. Cut the field coil connection at the switch post lead and remove small diameter ground wire from upper tab riveted to frame. Remove pole shoes and coils from frame.
9. Cut positive brush leads from field coils, as close to the field connection point as possible, if replacement is necessary. Refer to Step 5 of Cleaning and Inspection.

Cleaning and Inspection

1. Use a brush or air to clean the field coils, armature, commutator, armature shaft, brush end plate, and drive end housing. Wash all other parts in solvent and dry the parts.

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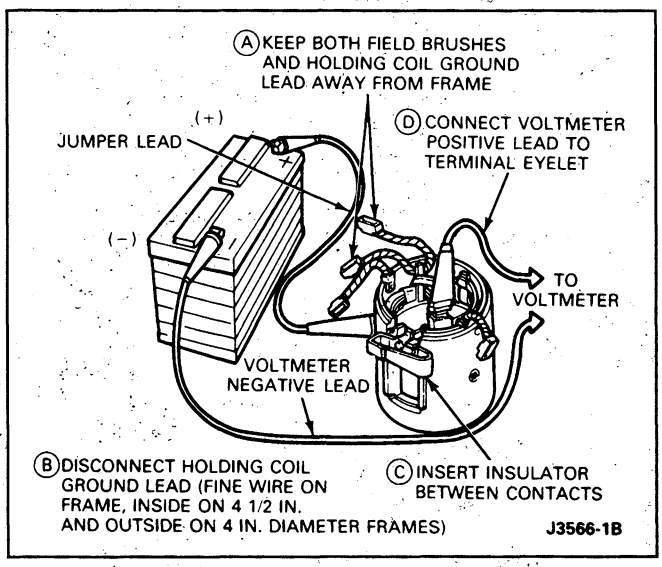


FIG. 5 Field Grounded Circuit Test

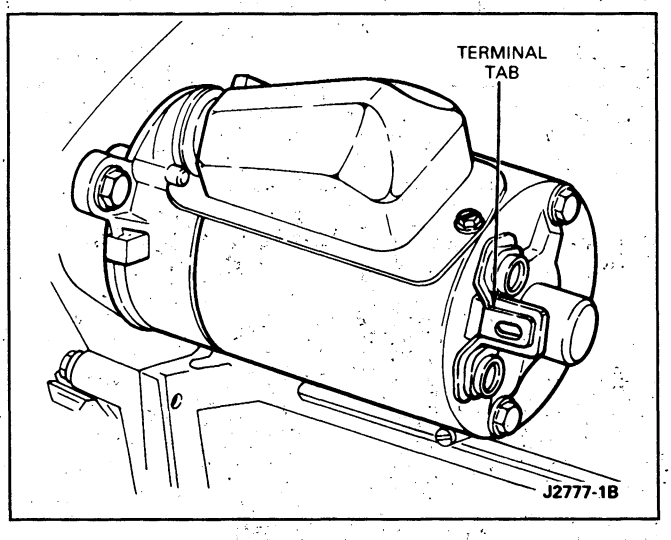


FIG. 6 Starter Mounting

2. Inspect armature windings for broken or burned insulation and unsoldered or open connections.
3. Check armature for open circuits and grounds.
4. Check commutator for runout (Fig. 10) using Dial Indicator TOOL-4201-C or equivalent. Inspect armature shaft and two bearings for scoring and excessive wear. If the commutator is rough or more than 0.127mm (0.005 inch) out-of-round, turn it down.
5. Check plastic brush holder for cracks or broken mounting pads. Replace brushes if worn to 6.35mm (1/4 inch) in length. Check field brush connections. A brush kit and contact kit are available. All other assemblies are to be replaced rather than repaired.
6. Examine wear pattern on starter drive teeth. The pinion teeth must penetrate to a depth greater than one-half the ring gear tooth depth (Fig. 11) to eliminate premature ring gear and starter drive failure.
7. Replace starter drives and ring gears having milled, pitted or broken teeth or that show evidence of inadequate engagement (Fig. 11).

Assembly

1. Position the three coils and pole pieces, then install attaching screws (Figs. 7 and 8). As the pole shoe screws are tightened, strike the frame several sharp blows with a soft-faced hammer to seat and align the pole shoes.
2. Install remaining coil and retainer and bend tabs to secure coils to frame (Fig. 12).
3. Position new insulated field brush lead on field coil terminal. Install clip provided with brushes to hold brush lead to terminal. Solder lead, clip, and terminal together using rosin core solder. Use a 300-watt iron.
4. Check for continuity and grounds in assembled coils.
5. The coil which is around retaining sleeve is to be grounded by positioning small diameter wire leading from it, under copper tab held by the rivet which attaches contact to frame.
6. Attach ground brushes to starter frame with screws. (Four-inch starter has copper rivets.)
7. Apply a thin coating of Lubriplate 777 or equivalent on the armature shaft splines. Install starter motor drive assembly to armature shaft and install a new retaining stop ring. Install a new stop retainer and thrust washer.
8. Install armature in starter frame.
9. Partially fill drive end housing bearing bore with Grease ESB-M1C63-A or equivalent (approximately 1/4 full). Position starter plunger lever to the frame and starter drive.
10. Position starter drive plunger lever return spring and drive end housing to frame. Install brush holder, and insert brushes and springs. Install brush holder insulator.
11. Position end plate to frame. Install and tighten through bolts to 6.21-8.47 N·m (55-75 in-lb). Do not pinch brush leads when installing end plate. Install pivot pin.
12. Position drive plunger lever cover and fasten to frame with cover screw.
13. Check starter no-load current draw.

Starter Drive Replacement

1. Remove starter plunger cover (Figs. 7 and 8).
2. Remove pivot pin retaining starter plunger lever.
3. Loosen through bolts enough to allow removal of drive end housing and lever return spring. Remove lever.
4. Remove thrust washer, drive stop ring retainer and stop ring from end of armature shaft and remove drive assembly.
5. Apply a thin coating of Lubriplate 777 or equivalent on armature shaft splines. Install drive assembly on armature shaft and install a new stop ring.
6. Position starter gear plunger lever on the starter frame. **Ensure lever properly engages drive flange.**
7. Install a new stop ring retainer and thrust washer. Partially fill drive end housing bearing bore with Grease ESB-M1C63-A or equivalent (approximately 1/4 full). Position lever return spring

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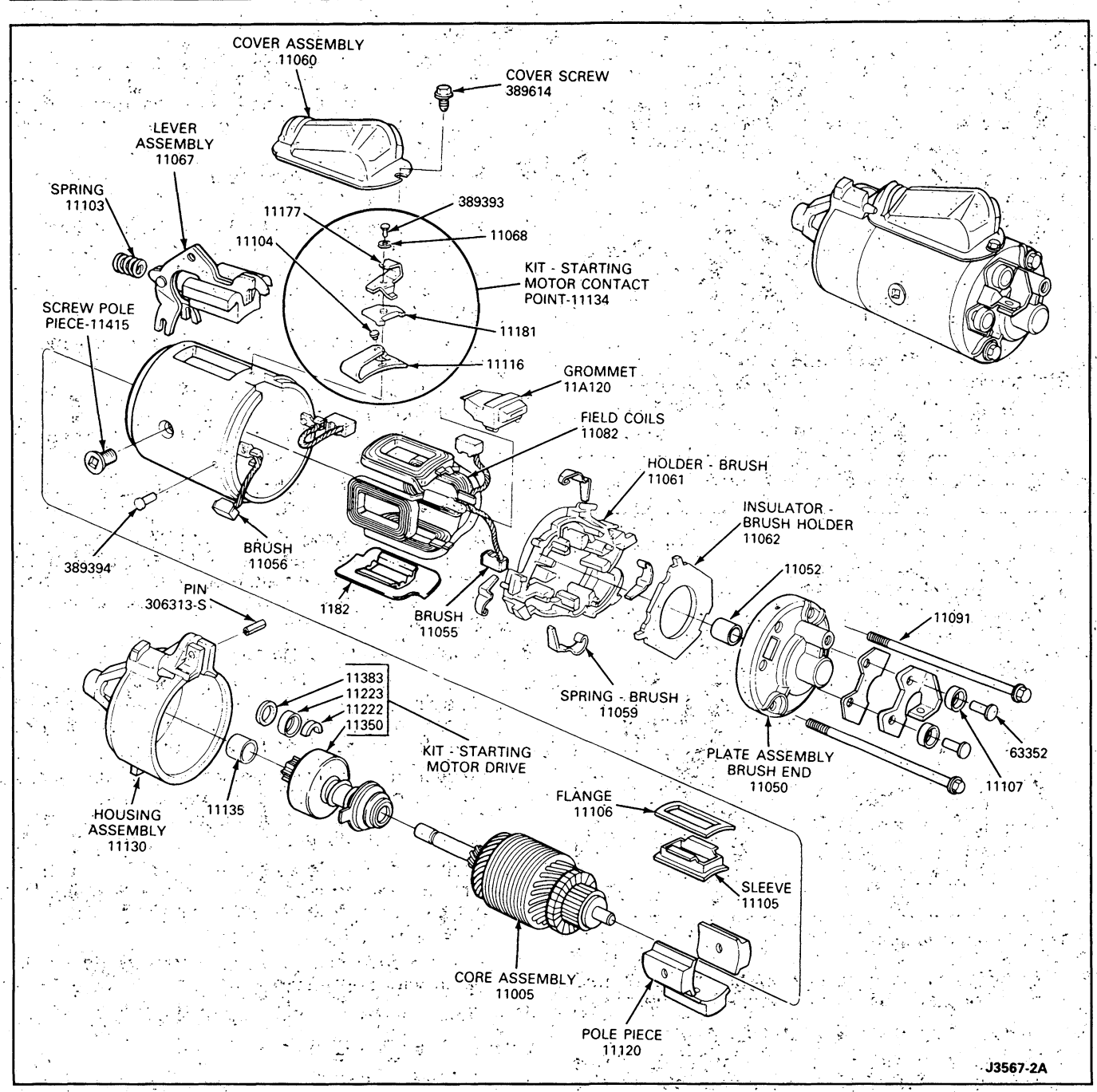


FIG. 7 Starter Disassembled (4-inch Starter—4.9L and 5.0L Engines)

and drive end housing to starter frame. Tighten through bolts to 6.21-8.47 N·m (55-75 in-lb). Install pivot pin.

8. Position starter drive plunger lever cover on starter. Tighten attaching screw.

Brush Replacement

Replace starter brushes when they are worn to 6.35mm (1/4 inch). Always install a complete set of new brushes.

1. Remove the two through bolts from starter frame.
2. Remove brush end plate, brush springs and brushes from holder.
3. Remove ground brush attaching screws or rivets from frame and remove brushes.
4. Cut insulated brush leads from field coils, as close to field connection point as possible.
5. Check plastic brush holder for cracks or broken mounting pads. Replace if necessary.
6. Position new insulated field brush lead on field coil connection. Position and crimp clip provided with brushes to hold brush lead to connection. Solder lead, clip, and connection together using a 300-watt iron and rosin core solder.
7. Install ground brush leads to frame with attaching screws or rivets.
8. Install brush holder and insert brushes in holder. Install brush springs. Positive brush leads should be positioned in their respective slots in brush holder to prevent potential grounding.

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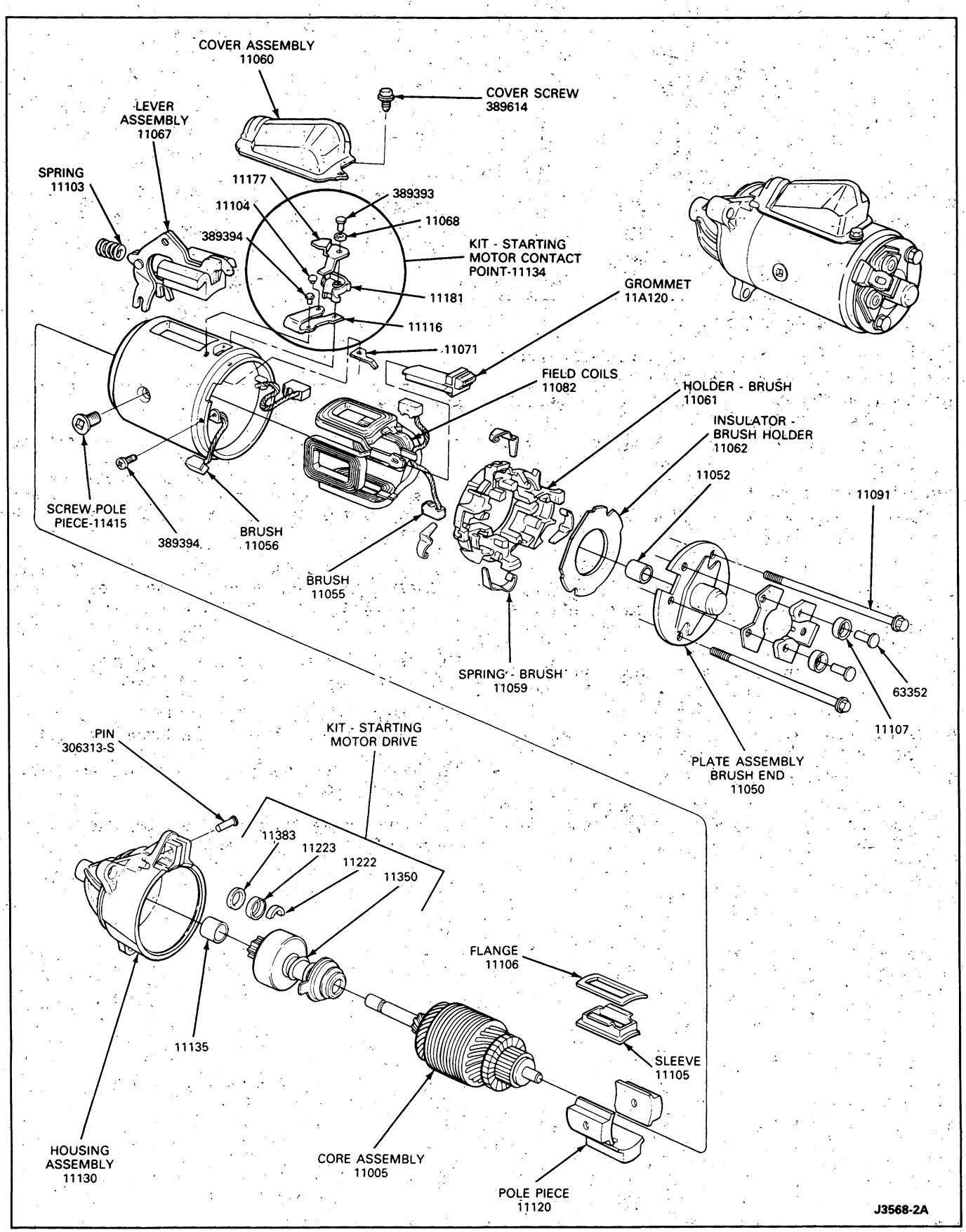


FIG. 8 Starter Disassembled (4.5-inch Starter—5.8L, 7.3L, and 7.5L Engines)

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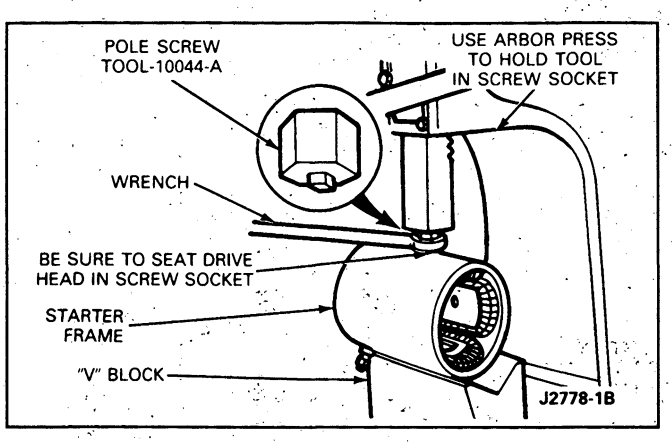


FIG. 9 Pole Shoe Screw Removal

9. Install brush end plate. Ensure end plate insulator is positioned properly on end plate.
10. Install two through bolts to starter frame. Tighten to 6.21-8.47 N·m (55-75 in-lb).
11. Secure starter in a vise. Connect starter to a battery to check its operation.

Armature Replacement

1. Remove starter drive plunger lever cover retainer screw and remove cover.
2. Remove pivot pin retaining starter plunger lever.
3. Remove through bolts, drive end housing, plunger lever, drive plunger lever return spring, and brush end plate. Remove brushes and lift out brush holder.
4. Remove armature. If starter drive assembly is being reused, remove stop ring from end of armature shaft, and remove drive.
5. Place drive assembly on new armature with a new stop ring, retainer and thrust washer.
6. Install armature in starter frame.
7. Position drive plunger lever to frame and drive assembly. Ensure lever properly engages drive flange.

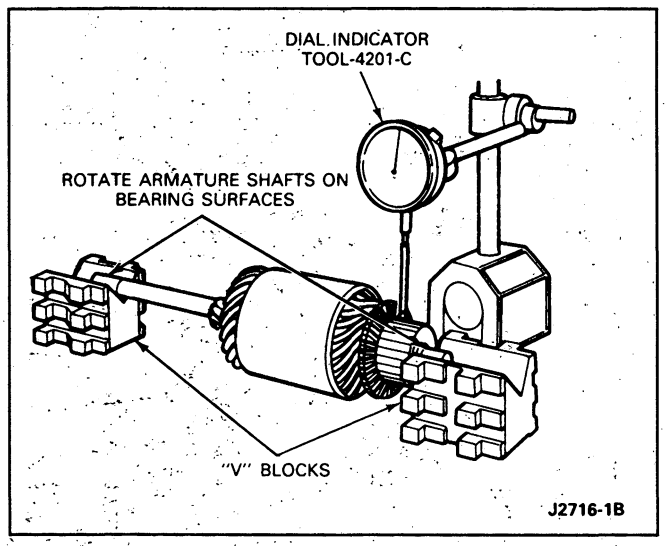


FIG. 10 Commutator Runout Check

8. Partially fill drive end housing bearing bore with Grease ESB-M1C63-A or equivalent (approximately 1/4 full). Position drive lever return spring, and drive end housing to starter frame. Ensure stop ring retainer is seated properly in drive housing.
9. Install brush holder and insert brushes in holder. Install brush springs. Positive brush leads should be positioned in their respective slots to prevent grounding.
10. Install brush end plate. Ensure end plate insulator is positioned properly on end plate.
11. Install two through bolts to starter frame. Tighten to 6.21-8.47 N·m (55-75 in-lb). Install pivot pin.
12. Install starter drive plunger lever cover and tighten retaining screw.
13. Check starter no-load current draw with starter secure in vise during test.

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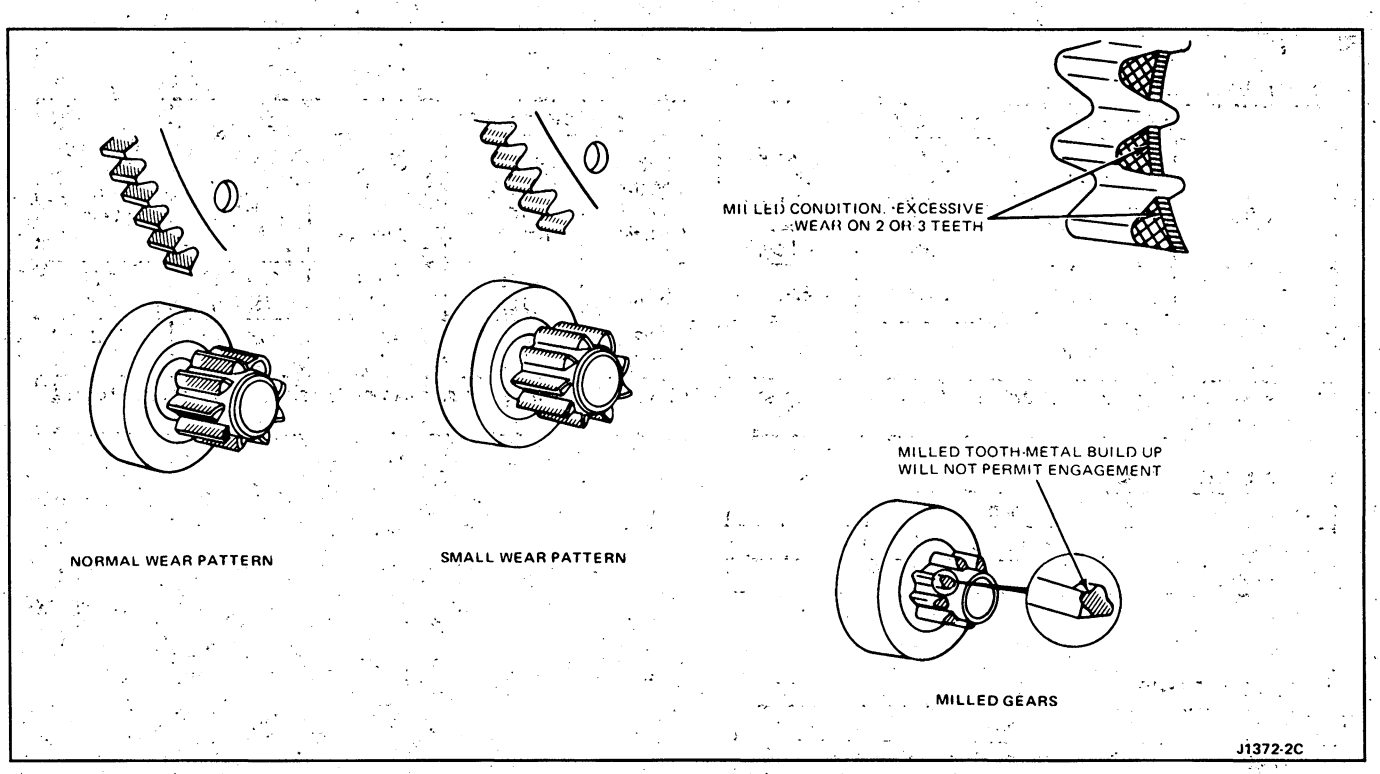


FIG. 11 Pinion and Ring Gear Wear Patterns

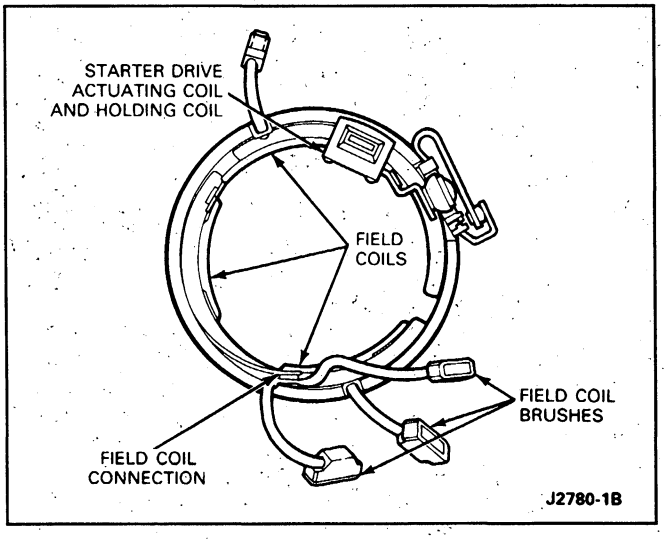


FIG. 12 Field Coil Assembly

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SPECIFICATIONS

POSITIVE ENGAGEMENT STARTER

Positive Engagement Starter Motor				Starter Brushes			Through Bolt Torque N-m (in-lbs)	Mounting Bolt Torque N-m (ft-lbs)
Dia. mm (Inches)	Current Draw Under Normal Load (Amps)	Normal Engine Cranking Speed (rpm)	Current Draw No. Load (Amps)	Mfg. Length mm (Inches)	Wear Limit mm (Inches)	Spring Tension kg (Ounces)		
101.60 (4)	150-200	180-250	60-85	12.2 (0.50)	6.35 (0.25)	1.134 (40)	6.21-8.47 (55-75)	21-27 (15-20)
114.30 (4.5)	150-180	150-290	70-85	12.2 (0.50)	6.35 (0.25)	1.134 (40)	6.21-8.47 (55-75)	21-27 (15-20)
Maximum Commutator runout is 0.1270mm (0.005 inch). Maximum starting circuit voltage drop (battery positive terminal to starter terminal) at normal engine temperature is 0.5 volt.								

SPECIAL SERVICE TOOLS

Tool No.	Description
T00L-10044-A	Starter Pole Screw Wrench
T00L-4201-C	Dial Indicator

CJ1430-2N

ROTUNDA EQUIPMENT

Model	Description
078-00005	Starting and Charging Tester

CJ3688-1B

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METRICS

INTRODUCTION

Most threaded fasteners are covered by specifications that define required mechanical properties, such as tensile strength, yield strength, proof load and hardness. These specifications are carefully considered in initial selection of fasteners for a given application. To assure continued satisfactory vehicle performance, replacement fasteners used should be of the correct strength, as well as the correct nominal diameter, thread pitch, length, and finish.

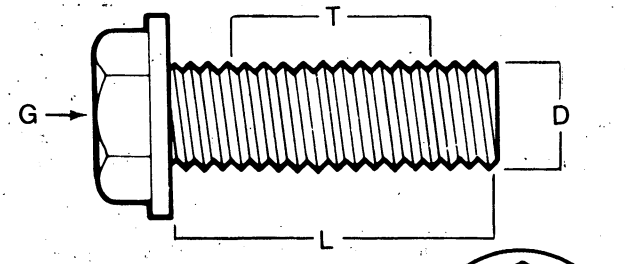
Most original equipment fasteners (English system or Metric) are identified with markings or numbers indicating the strength of the fastener. These markings are described in the pages that follow. Attention to these markings is important in assuring that the proper replacement fasteners are used.

Further, some metric fasteners, especially nuts, are colored blue. This metric blue identification is in most cases a temporary aid for production start-up, and color will generally revert to normal black or bright after start-up.

English system and metric system fasteners are available through your Ford Parts and Service operation.

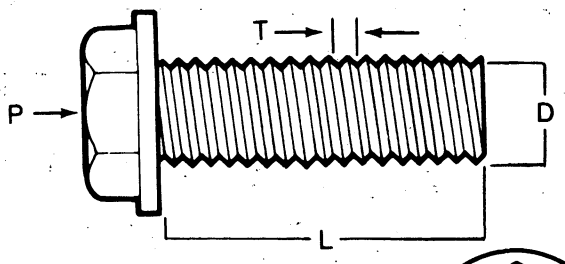
NOMENCLATURE FOR BOLTS

(ENGLISH) INCH SYSTEM
Bolt, 1/2-13x1

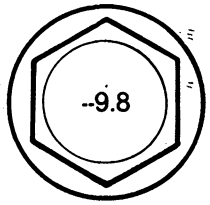


G—Grade Marking (bolt strength)
L—Length, (inches)**
T—Thread Pitch (thread/inch)
D—Nominal Diameter (inches)

METRIC SYSTEM
Bolt M12-1.75x25



P—Property Class* (bolt strength)
L—Length (millimeters)**
T—Thread Pitch (thread width crest to crest mm)
D—Nominal Diameter (millimeters)



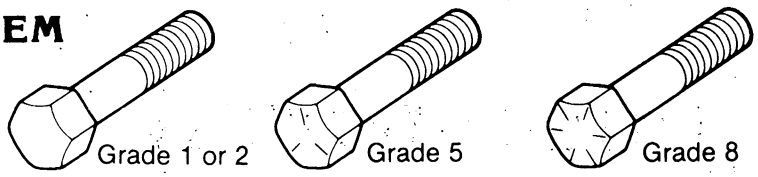
*The property class is an Arabic numeral distinguishable from the slash SAE English grade system.

**The length of all bolts is measured from the underside of the head to the end.

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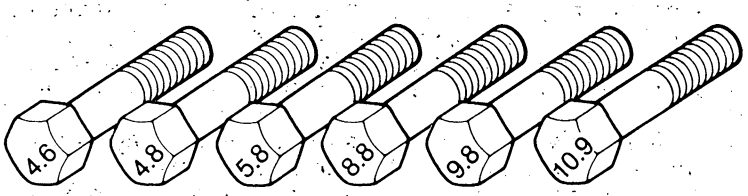
BOLT STRENGTH IDENTIFICATION

(ENGLISH) INCH SYSTEM



English (Inch) bolts—Identification marks correspond to bolt strength—increasing number of slashes represent increasing strength.

METRIC SYSTEM



Metric bolts—Identification class numbers correspond to bolt strength—increasing numbers represent increasing strength. Common metric fastener bolt strength property are 9.8 and 10.9 with the class identification embossed on the bolt head.

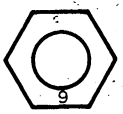
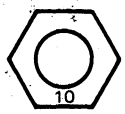
HEX NUT STRENGTH IDENTIFICATION

(ENGLISH) INCH SYSTEM

Grade	Hex Nut Grade 5	Hex Nut Grade 8
Identification		
	3 Dots	6 Dots

Increasing dots represent increasing strength.

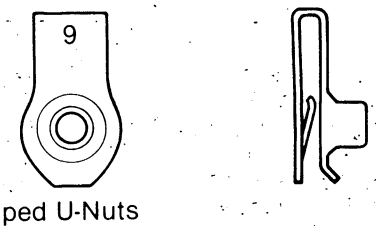
METRIC SYSTEM

Class	Hex Nut Property Class 9	Hex Nut Property Class 10
Identification		
	9 Arabic 9	10 Arabic 10

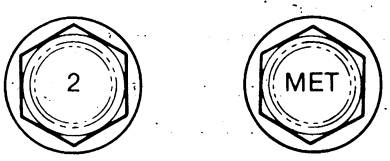
May also have blue finish or paint daub on hex flat. Increasing numbers represent increasing strength.

OTHER TYPES OF PARTS

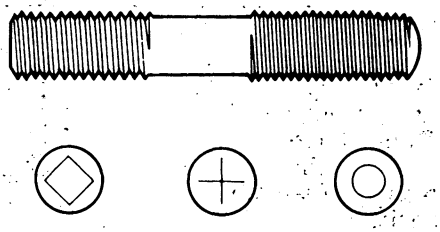
Metric identification schemes vary by type of part, most often a variation of that used of bolts and nuts. Note that many types of English and metric fasteners carry no special identification if they are otherwise unique.



—Stamped U-Nuts



—Tapping, thread forming and certain other case hardened screws



—Studs, Large studs may carry the property class number. Smaller studs use a geometric code on the end.

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ENGLISH METRIC CONVERSION

Description	Multiply	By	For Metric Equivalent
ACCELERATION	Foot/sec²	0.304 8	metre/sec² (m/s²)
	Inch/sec²	0.025 4	metre/sec²
TORQUE	Pound-inch	0.112 98	newton-metres (N·m)
	Pound-foot	1.355 8	newton-metres
POWER	horsepower	0.746	kilowatts (kw)
PRESSURE or STRESS	inches of water	0.2488	kilopascals (kPa)
	pounds/sq. in.	6.895	kilopascals (kPa)
	pounds/sq. in.	1	bar
ENERGY or WORK	BTU	1 055.	joules (J)
	foot-pound	1.355 8	joules (J)
	kilowatt-hour	3 600 000. or 3.6×10^6	joules (J = one W's)
LIGHT	foot candle	10.76	lumens/metre² (lm/m²)
FUEL PERFORMANCE	miles/gal	0.425 1	kilometres/litre (km/l)
	gal/mile	2.352 7	litres/kilometre (l/km)
VELOCITY	miles/hour	1.609 3	kilometres/hr. (km/h)
LENGTH	inch	25.4	millimetres (mm)
	foot	0.304 8	metres (m)
	yard	0.914 4	metres (m)
	mile	1.609	kilometres (km)
AREA	inch²	645.2	millimetres² (mm²)
		6.45	centimetres² (cm²)
	foot²	0.092 9	metres² (m²)
	yard²	0.836 1	metres²
VOLUME	inch³	16 387.	mm³
	inch³	16.387	cm³
	quart	0.016 4	litres (1)
	quart	0.946 4	litres
	gallon	3.785 4	litres
	yard³	0.764 6	metres³ (m³)
MASS	pound	0.453 6	kilograms (kg)
	ton	907.18	kilograms (kg)
	ton	0.90718	tonne
FORCE	kilogram	9.807	newtons (N)
	ounce	0.278 0	newtons
	pound	4.448	newtons
TEMPERATURE	degree farenheit	0.556 (°F -32)	degree Celsius (°C)

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DECIMAL AND METRIC EQUIVALENTS

Fractions	Decimal Inch	Metric mm
1/64	.015625	.397
1/32	.03125	.794
3/64	.046875	1.191
1/16	.0625	1.588
5/64	.078125	1.984
3/32	.09375	2.381
7/64	.109375	2.778
1/8	.125	3.175
9/64	.140625	3.572
5/32	.15625	3.969
11/64	.171875	4.366
3/16	.1875	4.763
13/64	.203125	5.159
7/32	.21875	5.556
15/64	.234375	5.953
1/4	.250	6.35
17/64	.265625	6.747
9/32	.28125	7.144
19/64	.296875	7.54
5/16	.3125	7.938
21/64	.328125	8.334
11/32	.34375	8.731
23/64	.359375	9.128
3/8	.375	9.525
25/64	.390625	9.922
13/32	.40625	10.319
27/64	.421875	10.716
7/16	.4375	11.113
29/64	.453125	11.509
15/32	.46875	11.906
31/64	.484375	12.303
1/2	.500	12.7

Fractions	Decimal Inch	Metric mm
33/64	.515625	13.097
17/32	.53125	13.494
35/64	.546875	13.891
9/16	.5625	14.288
37/64	.578125	14.684
19/32	.59375	15.081
39/64	.609375	15.478
5/8	.625	15.875
41/64	.640625	16.272
21/32	.65625	16.669
43/64	.671875	17.066
11/16	.6875	17.463
45/64	.703125	17.859
23/32	.71875	18.256
47/64	.734375	18.653
3/4	.750	19.05
49/64	.765625	19.447
25/32	.78125	19.844
51/64	.796875	20.241
13/16	.8125	20.638
53/64	.828125	21.034
27/32	.84375	21.431
55/64	.859375	21.828
7/8	.875	22.225
57/64	.890625	22.622
29/32	.90625	23.019
59/64	.921875	23.416
15/16	.9375	23.813
61/64	.953125	24.209
31/32	.96875	24.606
63/64	.984375	25.003
1	1.00	25.4

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TORQUE CONVERSION

NEWTON METRES (N·m)	POUND-FEET (LB-FT)
1	0.7376
2	1.5
3	2.2
4	3.0
5	3.7
6	4.4
7	5.2
8	5.9
9	6.6
10	7.4
15	11.1
20	14.8
25	18.4
30	22.1
35	25.8
40	29.5
50	36.9
60	44.3
70	51.6
80	59.0
90	66.4
100	73.8
110	81.1
120	88.5
130	95.9
140	103.3
150	110.6
160	118.0
170	125.4
180	132.8
190	140.1
200	147.5
225	166.0
250	184.4

POUND-FEET (LB-FT)	NEWTON METRES (N·m)
1	1.356
2	2.7
3	4.0
4	5.4
5	6.8
6	8.1
7	9.5
8	10.8
9	12.2
10	13.6
15	20.3
20	27.1
25	33.9
30	40.7
35	47.5
40	54.2
45	61.0
50	67.8
55	74.6
60	81.4
65	88.1
70	94.9
75	101.7
80	108.5
90	122.0
100	135.6
110	149.1
120	162.7
130	176.3
140	189.8
150	203.4
160	216.9
170	230.5
180	244.0

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Glossary

The glossary is a list of technical terms or acronyms and their definitions. It is not intended to be a dictionary of components and their functions. If you desire a detailed description of a specific component, refer to Section 3, Emission Related Components, in this manual.

A/CL BI MET (AIR CLEANER BI-METAL SENSOR).

A/CL CWM: See CWM.

A/CL DV (AIR CLEANER DUCT AND VALVE VACUUM MOTOR).

ACT (AIR CHARGE TEMPERATURE SENSOR): Air Charge Temperature Sensor or its signal line. Thermistor Sensor can be located in intake manifold (EFI Systems) or Air Cleaner.

ACTIVE CIRCUIT: A circuit consisting of some active (semiconductor) elements.

AIR BPV: See BPV.

ACV (AIR CONTROL VALVE): A vacuum controlled valve in the Thermactor system which diverts air pump air to either the upstream (exhaust manifold) or downstream (underbody catalyst) air injection points as required.

AFTERGLOW: The period of time the glow plug system on a diesel engine remains on after the engine is started.

ALTITUDE COMPENSATING MODULATOR: Device to control transmission shift spacing and engine timing. Improves performance at higher altitudes by changing the vacuum signals.

AMBIENT TEMPERATURE: Temperature of air surrounding an object.

ANTI-BFV (ANTI-BACKFIRE VALVE).

AUTOMOTIVE EMISSIONS: Gaseous and particulate compounds that are emitted from a car's crankcase, exhaust, carburetor, and fuel tank (hydrocarbons, nitrogen oxides, and carbon monoxide).

AXIS: A real or imaginary straight line on which an object rotates or is regarded as rotating.

BHS (BIMETAL HEAT SENSOR): A unit using a metallic part consisting of 2 layers with different metals, to sense temperature changes. The layers expand at different rates as temperature changes, causing the part to bend in a predetermined manner, thereby causing a changing signal.

BMAP (BAROMETRIC AND MANIFOLD ABSOLUTE PRESSURE SENSOR): Sensor housing containing both MAP and BP sensors. The barometric pressure sensor monitors atmospheric pressure and allows adjustment of spark advance, EGR flow, and air/fuel ratio as a function of altitude. The manifold absolute pressure sensor monitors engine vacuum and provides engine load information which is used to calculate spark advance, EGR flow and air/fuel ratio. See BP and MAP.

BP (BAROMETRIC PRESSURE SENSOR): An active circuit sensor (one half of BMAP sensor) or its signal line. Sensor signal is proportional to the Barometric Pressure at the sensor location.

B/P (EGR BACK PRESSURE VALVE).

BSV (BACKFIRE SUPPRESSOR VALVE): A device used in conjunction with the early design "Thermactor" exhaust emission system. Its primary function is to lean-out the excessively rich fuel mixture which follows closing of the throttle after acceleration. Allows additional air into the induction system whenever intake manifold vacuum increases.

BPV (BYPASS VALVE): A vacuum controlled valve in the Thermactor system which allows air from the air pump to be injected into the exhaust system, or bypassed to atmosphere when not required; and also provides a pressure relief function to protect the air pump from high pressure. These valves may be mounted on the air pump (pump mounted) or mounted in the Thermactor hose line (remote mounted). The two basic types are: normally closed (bypasses air with no vacuum signal applied) and normally open (allows air to flow through the valve to the exhaust system with no vacuum signal applied).

BV (BOWL VENT PORT).

CALIBRATION ASSEMBLY: Refer to ECA.

CANISTER: A container, in an evaporative emission control system, that contains charcoal to trap vapors from the fuel system.

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CANP (CANISTER PURGE SOLENOID): Electrical solenoid or its control line. Solenoid opens valve from fuel vapor canister line to intake manifold when energized. Controls flow of vapors between carburetor bowl vent and carbon canister.

CATALYST: A muffler-like device located in the exhaust system where hot exhaust gas comes in contact with special metals (i.e., platinum or palladium) that promote more complete combustion of unburned hydrocarbons and reduction of carbon monoxide.

CC (CATALYTIC CONVERTER): A muffler-like assembly placed in the exhaust system and containing a catalyst to change hydrocarbons and carbon monoxide into water vapor and carbon dioxide.

CDR (CRANCASE DEPRESSION REGULATOR): A device on a diesel engine used to regulate the amount of crankcase gases admitted into the intake manifold to be burned to lower engine emissions.

CHAMFER: A beveled edge or corner.

CHECK VALVE: A one-way valve which allows a liquid or gas to flow in one direction only — prevents backflow.

CO (CARBON MONOXIDE): A colorless, odorless gas that is a by-product of incomplete combustion of carbon. This gas is poisonous in confined spaces when it is at high concentration.

COC (CONVENTIONAL OXIDATION CATALYST): Acts on two of the major pollutants: HC and 9CO.

COMBINATION THERMACTOR AIR BYPASS AND AIR DIVERTER VALVE: Combines the function of a normally closed air Bypass Valve and an Air Control Valve in one integral valve.

COMPUTED TIMING: Relationship of Spark Plug Firing to CP pulse, expressed in crankshaft degrees. Since CP pulse is at 10 BTDC a Computed Timing reading of 10 would be equal to a Timing reading of 20 BTDC.

CP (CRANKSHAFT POSITION SENSOR): Permanent magnet with coil. Sensor produces AC pulse when magnetic field or sensor is disrupted by a gear tooth or notch. Senses pulse ring lobes. Resultant signal enables the ECA to determine when the ignition module should be triggered to produce a spark. Also, provides RPM information which is used to calculate spark advance and EGR flow, and air/fuel ratio, (replaces distributor centrifugal advance weights and timing pickup). One pulse is produced for each cylinder every other engine rotation (one for each spark plug firing). Example: 4 pulses are produced for each V8 engine rotation. The CP pulse is generated at 10 crankshaft degrees Before Top Dead Center (BTDC).

CP +: CP Sensor Signal line, Pin No. 18, TSS A-10.

CP −: CP Sensor return line. Connects to ground (Pin No. 8) in ECA Processor. Pin No. 2, TSS B-7.

CPRV (CANISTER PURGE REGULATOR VALVE).

CRANKSHAFT TIMING: Refer to Timing.

CRK: Cranking Signal. Battery Voltage that is switched to ECA by ignition switch during cranking (start) only. Pin No. 1, TSS A-2.

CSC (COOLANT SPARK CONTROL).

CSSA (COLD START SPARK ADVANCE SYSTEM): Added to the distributor spark control on some engines. System momentarily traps spark port vacuum on the distributor spark advance diaphragm when engine coolant temperature is below 53°C (128°F). Used in conjunction with a DRCV and a CSSA PVS.

CSSH (COLD START SPARK HOLD SYSTEM): Provides improved cold engine acceleration. When engine coolant is less than 53°C (128°F) the CSSH PVS is closed and the distributor vacuum signal travels through a restrictor proving a modified vacuum advance during the initial stage of acceleration.

CT (COMPUTED TIMING): Relationship of Spark Plug Firing to CP pulse, expressed in crankshaft degrees. Since CP pulse is at 10 BTDC a Computed Timing reading of 10 would be equal to a Timing reading of 20 BTDC.

CTAV (COLD TEMPERATURE ACTUATED VACUUM SWITCH): Used with MCU system to signal open loop or closed loop operating mode.

CV (CONTROL VALVE).

CWM (COLD WEATHER MODULATOR): A vacuum modulator located in the air cleaner on some models. Prevents the air cleaner duct door from opening to non-heated intake air when fresh air is below 13°C (55°F).

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DARLINGTON: A two transistor switch with transistors connected, so that their collectors are common and gains are multiplied.

DECELERATION VALVE: See DVAC.

DMS (DISTRIBUTOR MODULATOR SYSTEM): T/C.

DRCV (DISTRIBUTOR RETARD CONTROL VALVE): Used on engines equipped with the CSSA cold start spark advance system. Used in combination with a CSSA PVS.

DUAL CATALYTIC CONVERTER: See TWC.

DUTY CYCLE (DC): The measurement of the off (high voltage) time of the IMS pulse, expressed in percent.

DVAC (DISTRIBUTOR VACUUM ADVANCE CONTROL VALVE): A device used in conjunction with the dual diaphragm vacuum advance unit to advance timing under deceleration conditions.

DVCV: See DV/DV.

DV/DV (DIFFERENTIAL VALVE/DELAY VALVE): Installed in series with VDV. Used to delay sudden drops in manifold vacuum as during hard acceleration. Permits instant signal when deceleration occurs.

DV-TW (DELAY VALVE-TWO WAY).

DVVV (DISTRIBUTOR VACUUM VENT VALVE): Required by some engines to prevent fuel migration to distributor advance diaphragm and to act as a spark advance delay valve.

EARTH: Refer to Ground.

ECA (ELECTRONIC CONTROL ASSEMBLY): A vehicle computer consisting of a calibration assembly containing the computer memory and thus its control program and a processor assembly, which is the computer hardware. The calibration assembly plugs into the processor. The processor plugs into the vehicle harness.

ECT (ENGINE COOLANT TEMPERATURE SENSOR): Refers to thermistor sensor or its signal line. Sensor is immersed in engine coolant fluid. Provides engine coolant temperature information which is used to alter spark advance and EGR flow during warm-up or overheat conditions (replaces cooling and EGR PVS).

EDM (ELECTRONIC DISTRIBUTOR MODULATOR)

EEC (ELECTRONIC ENGINE CONTROL): A computer directed system of engine control. EEC-I — Control of engine timing. EEC-II — Control of engine timing and fuel (with FBC system). EEC-III — FBC-descendent of EEC-II EEC-III — EFI-control of engine timing and fuel (with EFI system).

EESS (EVAPORATIVE EMISSION SHED SYSTEM): A system for containment of evaporative fuel vapors introduced in 1978. Annual improvements have modified this system.

EFI (ELECTRONIC FUEL INJECTION): A system using fuel injectors, computer controlled, spraying fuel into a throttle body (CFI) or directly into the engine intake ports.

EGC (EXHAUST GAS CHECK VALVE): Allows thermactor air to enter exhaust manifold but prevents reverse flow in event of improper operation of other components.

EGO (EXHAUST GAS OXYGEN SENSOR): Exhaust Gas Oxygen Sensor or its signal Line. Sensor changes its output voltage as exhaust gas oxygen content changes when compared to oxygen content of atmosphere. Constantly changing voltage signal is sent to the ECA and MCU for analysis and adjustment of the A/F ratio.

EGOR (EGO SIGNAL RETURN): EGO signal return with separate ground on engine block.

EGR (EXHAUST GAS RECIRCULATION): A procedure where a small amount of exhaust gas is readmitted to the combustion chamber to reduce peak combustion temepratures and thus reduce NOx emissions.

EGR-ACT: EGR Solenoid pressure valve assembly.

EGR COOLER ASSEMBLY: Heat exchanger using engine coolant to reduce exhaust gas temperature.

EGRC (EGR CONTROL SOLENOID): Electrical solenoid or its control line. Solenoid switches engine manifold vacuum to operate EGR valve. Vacuum opens EGR valve when solenoid is energized.

EGRV (EGR VENT SOLENOID): Electrical solenoid or its control line. Solenoid normally vents EGRC vacuum line. When EGRV is energized, EGRC can open EGR valve.

EGR VA (EGR VALVE ACTUATOR).

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EPA (ENVIRONMENTAL PROTECTION AGENCY): Federal agency having responsibility for administrating congressional programs relating to the protection of the environment.

ERTN: Refer to EGOR.

ESC (ELECTRONIC SPARK CONTROL SYSTEM): An electronic distributor vacuum control system aiding in more complete combustion through controlled spark retard under certain temperature and speed conditions.

EVP (EXHAUST VALVE POSITION SENSOR): Potentiometric Sensor or its signal line. Sensor wiper position is proportional to EGR Valve pintle position. This allows ECA to determine actual EGR flow at any point in time.

EXHAUST GAS ANALYZER: An instrument for determining the amount of HC and CO emitted to the atmosphere. These instruments usually incorporate a "wheatstone bridge" to analyze the thermal conductivity of the mixture. A means of determining the efficiency with which the engine is then burning fuel.

EXHAUST HEAT CONTROL VALVE: A valve which routes hot exhaust gases to the intake manifold heat riser during cold engine operation. The valve can be thermostatically-controlled, or vacuum-operated.

FBC Feedback Carburetor System: A system of fuel control employing a computer controlled stepper motor that varies the carburetor fuel-air mixture.

FBCA (FEEDBACK CARBURETOR ACTUATOR): Controls carburetor air/fuel ratio. A system of fuel control employing a computer controlled stepper motor that varies the carburetor fuel-air mixture.

FDV (FUEL DECEL VALVE): A valve which, during deceleration, adds additional air-fuel to the intake manifold to enrich the air-fuel mixture and thus provide for more complete combustion. See DVAC.

FP (FUEL PUMP RELAY): Relay or its control line. Relay is controlled by ECA processor. Supplies power to electric fuel pump of EFI system.

FUEL-VACUUM SEPARATOR: Used to filter waxy hydrocarbons from carburetor ported vacuum to protect vacuum delay valve and distributor vacuum controls.

FULCRUM: The pivot point of a valve rocker arm on an engine.

GLOW PLUG: An electronically operated device used to heat up the combustion chamber in a diesel engine to aid in starting.

GND. (or) GROUND: Common line for all vehicle power, vehicle chassis ground and engine block ground, connected to vehicle battery negative terminal.

HC (HYDROCARBON): Any compound composed of carbon and hydrogen, such as petroleum products. Excessive amounts in the atmosphere are considered undesirable contaminants and a major contributor to air pollution.

HCV (EXHAUST CONTROL VALVE).

HEADER: The portion of a diesel fuel injection pump which distributes fuel to the individual cylinders.

HIC (HOT IDLE COMPENSATOR): A thermostatically controlled carburetor valve that opens whenever inlet air temperatures are high. Additional air is allowed to discharge below the throttle plates at engine idle. This feature improves idle stability and does not allow the rich fuel mixture normally associated with increased fuel vaporization of a hot engine.

IAT (INTAKE AIR TEMPERATURE SENSOR): Refer to ACT.

IDLE LIMITER: A device to control minimum and maximum idle fuel richness of the carburetor. Aids in preventing unauthorized persons from making overly rich idle adjustments. The limiters are of two distinct types: the external plastic limiter caps installed on the head of idle mixture adjustment screws or the internal needle-type located in the idle channel.

IDLE VACUUM VALVE: This device may be used in conjunction with other vacuum controls to dump thermactor air during extended period of idle. Provides protection to the catalyst.

IGNITION PRESSURE SWITCH ASSEMBLY: Pressure switches used on turbocharged engines in conjunction with dual mode ignition to retard spark timing during boost to prevent engine damage.

IMS (IGNITION MODULE SIGNAL): The signal produced by the ECA that controls the ignition module ON and OFF time and therefore the spark plug timing and coil dwell.

INERTIA SWITCH: EFI system switch. Designed to shut off electric fuel pump if vehicle receives severe rear end impact.

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INJECTOR: EFI System Electrical Solenoid or its control line. Solenoid, when energized, allows fuel flow.

IPS (IGNITION PRESSURE SWITCH).

ITVS (IGNITION TIMING VACUUM SWITCH).

IVV (IDLE VACUUM VALVE).

LCV (LOAD CONTROL VALVE).

LEAKDOWN RATE: The period of time it takes for a valve tappet to collapse when being tested on a leakdown tester.

LINEAR: Similar to straight line. Directly proportional. Example: A linear circuit would produce 1X out with 1Y in 3X out with 2Y in a 9X out with 3Y in.

LOS (LIMITED OPERATIONAL STRATEGY): Certain types of computer malfunction will place the ECA into the LOS mode. Output commands are cut off the important control solenoids.

MAP (MANIFOLD ABSOLUTE PRESSURE SENSOR): An active circuit sensor (one-half of BMAP sensor) or its signal line. Sensor signal is proportional to the absolute pressure of intake manifold.

MCT (MANIFOLD CHARGE TEMPERATURE SENSOR): Refer to ACT.

MCU (MICROPROCESSOR CONTROL UNIT): Integral part of electronically controlled feedback carburetor system using TWC catalyst. Various sensors monitor mode conditions. MCU is now widely used on Ford-built vehicles for the control of air/fuel ratios.

MCV (MANIFOLD CONTROL VALVE): A thermostatically operated valve in the exhaust manifold for varying heat to intake manifold with engine temperature.

MONOLITHIC SUBSTRATE: The ceramic honeycomb structure used as a base to be coated with a metallic catalyst material for use in the converter.

NOx (NITROGEN OXIDES): A compound formed during the engine's combustion process when oxygen in the air combines with nitrogen in the air to form the nitrogen oxides which are agents in photochemical smog.

PASSIVE CIRCUIT: A circuit consisting of all passive elements. Resistors, capacitors, or inductors.

P.C.V. (POSITIVE CRANKCASE VENTILATION): A valve which controls the flow of vapors from the crankcase into the engine intake system where they are burned in the engine cylinders rather than being discharged unburned into the air from the crankcase.

POSITIVE VALVE ROTATOR: A device at the base of the valve spring assembly used to rotate the valve slightly each time the valve is opened. This action prevents the buildup of carbon on the valve face and valve seat.

POTENTIOMETER: (POT), a variable resistor with three connections. The third connection (wiper) moves physically up and down the resistive element which has each end attached to one of the other two connections.

POTENTIOMETRIC PROCESSOR: Like a potentiometer.

PPS (PORTED PRESSURE SWITCH).

PROCESSOR ASSEMBLY: Refer to ECA.

PTC (POSITIVE TEMPERATURE COEFFICIENT HEATER): A temperature sensitive electric assist choke system activated when ambient temperature is above 16°C (60°F). Permits earlier opening of the choke plates to reduce fuel consumption.

PURGE CV (PURGE CONTROL VALVE).

PVS (PORTED VACUUM SWITCH): A temperature-actuated switch that changes vacuum connections when the coolant temperature changes.

RATED RPM: The maximum RPM of a diesel engine run at wide open throttle.

RATIO: The proportion of a value divided by another.

RATIOMETRIC: As used in EEC-A voltage divided by the VREF multiplied by 10.

RATIO-METRICALLY: Similar to a Ratio. Refer to Ratiometric for specific EEC meaning.

RELAY: A switching device operated by a low-current circuit, which controls the opening and closing of another circuit of higher current capacity.

RELIEF VALVE: A pressure limiting valve located in the exhaust chamber of the air supply pump. Functions to relieve part of the exhaust air flow if the pressure exceeds the pre-determined value.

ROTARY INJECTION PUMP: A type of diesel injection pump which rotates and distribute fuel to the individual cylinders at precisely timed intervals.

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SA-FV (SEPARATOR ASSEMBLY — FUEL VACUUM).

SC (SIGNAL CONDITIONER)

SDV (SPARK DELAY VALVE): A valve which delays spark vacuum advance during rapid acceleration from idle or from speeds below 15 mph, and to cut off spark advance immediately on deceleration. Has internal sintered orifice to slow air in one direction, a check valve for free air flow in opposite direction and a filter.

SHED (SEALED HOUSING EVAPORATIVE DETERMINATION SYSTEM): See EESS.

SILN (SILENCER-EXHAUST AIR SUPPLY).

SOLENOID: A wire coil with a movable core which changes position by means of electromagnetism when current flows through the coil.

SOL V (EGR SOLENOID VACUUM VALVE ASSEMBLY).

SPACER ENTRY EGR SYSTEM: Exhaust gases are routed directly from exhaust manifold through stainless steel tube to carburetor base.

SPK OR SPARK: Refer to IMS.

SRTN (SENSOR RETURN LINE): A return line for all sensors, except EGO and CP.

SV-CBV (SOLENOID VALVE-CARBURETOR BOWL VENT): See SVV.

SVV (SOLENOID VENT VALVE): Energized by ignition switch to control fuel vapor flow to canister. Ignition off opens valve.

TAB (THERMACTOR AIR BYPASS SOLENOID): Electrical Solenoid or its control line. Solenoid switches engine manifold vacuum. Vacuum bypasses thermactor air to atmosphere.

TAD (THERMACTOR AIR DIVERTER SOLENOID): Electrical Solenoid or its control line. Solenoid switches engine manifold vacuum. Vacuum switches thermactor air from downstream (past EGO sensor in exhaust system) to upstream (before EGO sensor) when solenoid is energized.

TAV (TEMPERATURE ACTUATED VACUUM)

TDC (TOP DEAD CENTER): The point of rotation of the crankshaft when the piston is at the top of its stroke.

THERMACTOR: An air injection type of exhaust emission control system. Similar to exhaust emission control systems used by G.M. and American Motors vehicles. A product identification name of Ford Motor Company.

THERMACTOR II: This is a pulse air system which utilizes the natural exhaust pulses in a tuned pipe. A reed-type check valve responds to the negative pressure pulses so generated and permits air to be drawn into the exhaust system.

THERMISTOR: A resistor that changes its resistance with temperature.

TIMING: Relationship between Spark Plug firing and piston position, usually expressed in crankshaft degrees before or after Top Dead Center (TDC) of compression stroke. Example: 15 degrees BTDC.

TIV (THERMACTOR IDLE VACUUM VALVE): Used in some evaporative emission systems to improve engine idling after a hot start.

TKA (THROTTLE KICKER ACTUATOR): See TK or TKS.

TKS (THROTTLE KICKER SOLENOID): Electrical Solenoid or its control line. Solenoid, when energized, supplies manifold vacuum to throttle kicker actuator as directed by the ECA. Actuator moves throttle linkage to increase idle rpm. TKS vents the actuator vacuum line when de-energized.

TP (THROTTLE POSITION SENSOR): Potentiometric sensor or its signal line. Sensor wiper position is proportional to throttle position. Defines engine operation mode: closed, part or wide open throttle. (Replaces carburetor spark/EGR ports).

TRANSDUCER: An electrically actuated vacuum regulator.

TRS OR TRS + 1 (TRANSMISSION REGULATED SPARK CONTROL SYSTEM): A distributor vacuum control system aiding in more complete fuel combustion by regulating spark retard when the outside air temperature is above 60°F. The system uses a switch responding to the gear range, or hydraulic pressure in the transmission, to regulate a vacuum control valve.

TSP (THROTTLE SOLENOID POSITIONER): A device for providing variable throttle stops. A higher position for maintaining the specified idle rpm, and a lower position, when the ignition is turned OFF, to prevent dieseling. Can be used to increase throttle opening when air conditioning is turned on.

TSP-VOTM (TSP-VACUUM OPERATED THROTTLE MODULATOR).

TVS (THERMAL VACUUM SWITCH): Used with some ported EGR systems. Located in the carburetor air cleaner to control vacuum to the EGR valve, instead of a PVS valve. Responds to temperature of the inlet air heated by the exhaust manifold.

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TVV (THERMAL VENT VALVE): Temperature sensitive valve assembly located in the canister vent line. Closes when engine is cold and opens when hot. Prevents fuel tank vapors from being vented through the carburetor fuel bowl when fuel tank heats up before engine compartment.

TWC (THREE WAY CATALYST): Sometimes referred to as a dual catalytic converter. Combines two converters in one shell. Controls NOx, HC and CO.

VACUUM: A term used to describe a pressure that is less than atmospheric pressure; hence, a partial vacuum. Used for control purposes throughout the automotive industry.

VACUUM ADVANCE: Advances ignition timing with relation to engine load conditions. This is achieved by using engine intake manifold vacuum to operate the distributor diaphragm.

VACUUM REGULATOR: Provides constant vacuum output when vehicle is at idle from manifold. Switches to engine vacuum at off idle.

VACUUM REGULATOR/SOLENOID: Regulator valve provides vacuum to feedback carburetor. Solenoid is controlled by ECA to provide feedback carburetor control.

VACUUM RETARD DELAY VALVE: Delays the loss of vacuum signal during some vehicle deceleration modes.

VACVV-D (DISTRIBUTOR VACUUM AND VENT CONTROL VALVE).

VACVV-T (THERMACTOR VACUUM AND VENT CONTROL VALVE).

VACW-D (VENT VALVE VACUUM AND VENT CONTROL VALVE).

VACW-D (VENT VALVE VACUUM-DELAY): Delays vacuum to the distributor through a sintered disk.

VBAT: Vehicle Battery, Battery Voltage, Pin No. 24, TSS A-1.

VCKV (VACUUM CONTROL CHECK VALVE).

VCS (VACUUM CONTROLLED SWITCH).

VCTS (VACUUM CONTROL TEMPERATURE SENSING VALVE): A valve that connects manifold vacuum to the distributor advance mechanism under hot idle conditions.

VCV (VACUUM CHECK VALVE): Used to retain vacuum signal in system after vacuum source is gone.

VCS-CT (VACUUM CONTROLLED SWITCH — COLD TEMPERATURE).

VCS-DI (VACUUM CONTROLLED SWITCH — DECEL IDLE).

VDV (VACUUM DIFFERENTIAL VALVE): A valve used in the Thermactor system with catalyst to cutoff vacuum to the air bypass valve during deceleration.

VECI (VEHICLE EMISSION CONTROL INFORMATION DECAL): Critical specifications for servicing emission systems. Decal located in engine compartment.

VISCOSITY: The rating of an engine oil's resistance to flow.

VOTM (VACUUM OPERATED THROTTLE MODULATOR).

VRDV (VACUUM RETARD DELAY VALVE): A valve which delays a decrease in vacuum at the distributor vacuum advance unit when the source vacuum decreases.

VREF (REFERENCE VOLTAGE): A power supplied by ECA to some sensors regulated at a specific voltage between 8 and 10.

VRESER (VACUUM RESERVOIR).

VREST (VACUUM RESTRICTOR).

VR/S (VACUUM REGULATOR/SOLENOID).

VRV (VACUUM REGULATOR VALVE): Three port valve.

VVA (VENTURI VACUUM AMPLIFIER): Used with some EGR systems so that carburetor venturi vacuum can control EGR valve operation. Venturi vacuum is desirable because it is proportional to the air flow through the carburetor.

VVV (VACUUM VENT VALVE).

WIPER: Refer to potentiometer.

WOT (WIDE OPEN THROTTLE VALVE): In some EGR applications, it is desirable to cutoff EGR flow at wide-open throttle, where a richer fuel mixture is needed for performance. Valve is vacuum actuated when "full throttle" signal is received from the carburetor.

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